GEOLOGICAL SURVEY.

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THIRD REPORT

OF THE

GEOLOGICAL SURVEY

IN

KENTUCKY,

MADE DURING THE YEARS 1856 AND 1857,

BY

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PRINCIPAL GEOLOGIST,

ASSISTED BY

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INTRODUCTORY LETTER.

HIS EXCELLENCY C. S. MOREHEAD,

GOVERNOR OF KENTUCKY:

SIR—Since the Second Report went to press the Geological Survey of the counties not previously examined has been instituted, and I now have the honor of submitting my Third Report, comprising the result of that exploration, as well as that of those portions of the state not previously reported on.

This report also embraces the Chemical, Topographical, and Paleontological Reports that have been completed since last June, and embodies much important and practically useful matter.

The melancholy accident which caused the death, by drowning, of one of the members of the geological corps last August—Edward Mylotte—has been a most unfortunate affair, not only for his family but for the survey, since he was the Topographical Engineer who had charge of corps, No. 3, in Greenup county, and had run most of the lines and recorded the topography of that county. Just before his death he had been engaged in the office working up his materials, and drawing the topography of Greenup county, which work was only partially completed. A substitute was obtained as soon as possible, who, with the aid of the Topographical Assistant, have been endeavoring to complete this map from Mr. Mylotte's field-notes; but it will be impossible for either of them to do it in as satisfactory manner as the individual who ran most of the lines and made the notes on the spot. This misfortune has greatly retarded the office work on the Greenup county map.

A delay was also occasioned on the base line, by the fall of one of the men when carrying the transit theodolite across a stream in Breck-

inridge county, which threw the instrument out of axis, rendered it necessary that it should go to a philosophical instrument-maker for repairs. To avoid expense the party had to be discharged until these repairs could be made. The base line party was to resume its work early in October.

D. D. OWEN,
State Geologist.

PART FIRST

OF THE

THIRD GEOLOGICAL REPORT

OF

KENTUCKY.

CHAPTER I.

COAL MEASURES.

In the second volume of the Geological Report, on page 64, it has been stated that a Paleontological Survey of the Western Coal Measures of Kentucky would be undertaken sometime during this season, for the purpose of aiding in establishing the identity of the various coal beds of the Kentucky coal field, and in order to draw comparisons between the Kentucky coal fields and those of other states, particularly Pennsylvania.

That work has been fairly commenced, and already some interesting and practically useful results have been obtained, which the reader will find by consulting the Paleontological Report of M. Leo Lesquereux, appended to this volume, as well as that of Mr. Edward Cox.

In this chapter I shall first make some remarks in regard to some of the inferences in that report, which I consider still open for investigation, together with some general remarks bearing on important facts, to which I desire especially to call the attention of my readers.

Our experience, so far, in the Western coal field of Kentucky, leads to the conclusion that there is no reliable workable coal below the pebbly sandstone, or Caseyville conglomerate; but there are many instances in the Eastern Kentucky coal field where workable coal occurs below the lowest conglomerate, even, in several instances, within fifteen feet of the upper surface of the sub-carboniferous limestone. This is the case in Bath, Powell, Pulaski, and probably also in Rowan and Madison counties.

The Paleontological evidence, so far, is in favor of but one coal, No. 1, B, of the Paleontological Report, in the shaly space immediately above the conglomerate, where two have been previously laid down in some of the sections. This is a question which I still consider not conclusively settled, because there are some statements, insisted on by the Topographical Assistant, which lead certainly to the belief of a coal below Bell's coal, (No. 1, B;) for instance, it is affirmed that a coal was discovered in the Spigart shaft, at a depth fifty to seventy feet below the level of the Bell coal, No. 1, B.

Again: Mr. Samuel Casey, who has had practical experience amongst the coals of Union county, informs me that he struck a twenty-eight-inch coal down in a well sunk on the back or west side of the Caseyville bluff, only seventy to one hundred paces from a drift above the drainage of the country made into No. 1, B, and this coal was reached in the well some fifty to seventy feet below the entrance into said drift. If this is the case then one of two things necessarily follows: either there is a lower coal, No. 1, A, in this region, or there is a slip or fault, that has been overlooked, somewhere between the top of this well and the drift into the coal immediately west of it, which all agree is No. 1, B. Moreover, the same gentleman states that this lower coal, No. 1, A, is twenty feet below the coal worked by his brother, which is No. 1, B, the same as the Bell coal; here, however, he finds No. 1, A, to be only twenty inches thick. He also states that he believes it to exist at Bell's, about seventy feet below that coal, though he has never seen it opened, because it occurs at these other localities, and because it has been struck in the clay in sinking wells at Bell's mines, but only a few inches in thickness. In the tough shale roof of this lower coal he has usually found peculiar shaped ironstone segregations, which he has not observed in the roof of the Bell coal which is usually what the miners call "gray metal."

In the face of these assertions it would not be safe to deny the existence of coal No. 1, A, until further investigations are instituted, especially since this coal is admitted to exist in some parts of Pennsylvania and perhaps Ohio also, as two members, lying at variable distances apart—that is, in some parts of the state the coal in the shaly space above the conglomerate has occasionally two members lying, sometimes, close together, or even united into one bed; at other times, diverging from one another, until they are separated by a space of forty feet of shale or more, and even divided, in some instances, into three members. It is because these coals are sometimes united into one bed that we have represented them by one number, designating the different members by the letters A, B, C, according as one, two, or three members may be found.

The question to be decided in western Kentucky is, whether this coal is united as one or separated into two members, lying forty to seventy feet apart? M. Leo Lesquereux is of opinion, because coal

No. 1, B, wherever he has seen it in the western coal field, has a rash-coal at the bottom, that it is here united into one bed, since where he has observed this rash-coal in Pennsylvania, it was always at the base of coal No. 1, A; but as this structure of coal may be due to a cause liable to be repeated in two or more coal beds we think this evidence alone not altogether conclusive. At all events, it is still necessary that further and more extended observations should be made in this part of the coal region, which may settle this very important practical question for the inhabitants of the Tradewater valley.

There are two small coals, which lie respectively forty-five and seventy feet above the Bell coal, No. 1, B; one of these may be in the place of the Great Repository of cannel coal of Pennsylvania, as well as the main cannel bed of the Eastern Kentucky coal field. The paleontological evidence of the place of this coal is, however, as yet, wanting in western Kentucky; and M. Leo Lesquereux is disposed to think it possible that it may be represented in Union county, merely by the thin cannel band frequently found on the top of coal No. 1, B.

In many parts of Pennsylvania there is a conspicuous limestone, known as the lower fossiliferous limestone, often overlaid by a kind of buhrstone, or a layer of pure quartzose sandstone, which is often interposed below the shale underlying the cannel coal, and not unfrequently with bands and segregations of iron in the shale above and below this limestone. No corresponding limestone has yet been recognized in the Western coal field, nor yet the buhrstone, but the shales, with iron ore, are indicated, which lends some probability to the correctness of the geological horizon.

This coal would come in as No. 2 in the series, but is certainly not the same coal referred to, by M. Leo Lesquereux, under the head of No. 2, near the Mulford mines, as we shall show hereafter, which shows itself in a ravine on section 24, T. 3, N., about a mile and a half east of north of Caseyville.

Those interested in coal lands lying towards the base of the Coal Measures, will do well to bear in mind the place of No. 2 coal, since, being the position of fine beds of cannel coal in the Pennsylvania coal field, according to Leslie, it is always possible that, in the Western coal field, this horizon might afford a sufficient thickness of this valuable variety of oil-producing coal. It is to be sought for in the shaly space

beneath contorted Sigillaria, Lepidodendron, and Calamites sandstone, which has the lithological and paleontological characters of the sandstone mass forming the Finnie Bluff, above Caseyville, in Union county, or elsewhere under equivalent sandstones. This sandstone is remarkable, not only for the irregular contorted condition of its beds, but also for the number of fragments, lenicular masses, and imperfect seams of coal, enclosed especially towards its base, as well as the abundance of Sigillaria, Lepidodendrons, and Calamites which it contains.

The upper part of this member of the Coal Measures, for about fifteen feet, is composed of sandy shale, the middle forty feet are brown sandstones. The lower twenty-two feet is very variable in composition, as will be perceived by the following enumeration of its individual layers, near Caseyville, in Union county:

	Ft. In.
Hard sandstone,	1.2
Soft shales, containing irregular bands of iron,	1.7
Solt shales,	1.0
Hard irregularly weathering sandstone,	2.0
Sandy shales,	3.0
Sandstone,	2.4
Sandy shales,	2.0
Hard sandstone,	1.0
Shales with nodular iron,	.6
Sandstone, with irregular concretions,	.9
Sandstones, fractured, bent and thrust together,	.2
Sandstone,	.4
Shales and sandy shales,	.1
Hard sandstone,	1.4
Dark-blue and grey shales, with concretionary sandstone white and grey,	.8
Sandy shales with iron pyrites,	1.4

In a corresponding geological position in Pennsylvania, a sandstone of very similar character occurs; but the shaly space between it and their great cannel coal horizon is often as much as seventy-five to one hundred feet, embracing two beds of coal of one to one and a half feet.

Coal No. 3, above the foregoing described sandstone, has only been observed, as yet, satisfactorily in Union county, under the name of the "Ice-house coal." The paleontological characters of the roof of this coal are, up to the present time, only very imperfectly ascertain-

ed. It is, as we have shown in the previous volume*, a coal perhaps better adapted for manufacturing iron than any of the coals in the lower five hundred feet of the measures, more especially as its hard grey shale roof encloses, where it has been opened, good bands of iron ore, of which an analysis is given on pages 57 and 58 of the first Geological Report. The bed of coal in Pennsylvania corresponds to this coal, judging, however, at present, only from order of superposition, appears to be quite a persistent bed of excellent quality, usually about three feet thick, but thickening to eight feet on Broad Top Mountain.

The paleontology of the roof of coal No. 4 seems to be better defined, at present, by its fossil plants, than any of the coals of the Western Coal Field. They are considered by M. Lesquereux to be identical in species with those found in Pennsylvania, over the coal that underlies the Mahoning sandstone, and in the roof of the Pomeroy coal of Ohio.

Since M. Lesquereux left Kentucky he made a visit to Ohio for the special purpose of investigating the true geological horizon of the Pomeroy coal, and has now fully satisfied himself that it is properly placed below the Mahoning sandstone, and that it is the equivalent of the Giger bed, No. 4, of his report of Western Kentucky. Unfortunately, M. Lesquereux did not get a view of the coal with *two clay* partings, in the Curlew Hill, between the Curlew mines and Mulford's mines, on the southwest of section 15, T. 3 N., R. 1 W. of the Ohio river; but there is little doubt, when its paleontology is investigated, that it will prove to be the same bed; the superposition of this bed in the series, the two clay partings, the underlying Curlew limestone, and its position below the Curlew sandstone, the second principal mass of thick sandstone, above the conglomerate, all tending to predict this as its true geological position, and if so, then the Curlew sandstone is on the geological horizon of the well known Mahoning sandstone of Pennsylvania, which marks the base of the "Barren Coal Measures" of that state, where it is, sometimes, a conglomerate or pebbly sandstone.

Above this sandstone, in Pennsylvania, there are upwards ef four hundred feet of strata extending up to the bottom of the Pittsburg

*1st volume Geological Report on Kentucky, page 55.

coal, in which only thin beds of coal occur that are not workable, and hence are denominated "Barren Coal Measures." In the corresponding space in the Western Coal Measures of Kentucky we find a marked difference. In the space of three hundred and forty feet above the top of the Curlew sandstone we have three good coals, varying in thickness from three to five feet each; and one of them is one of the most reliable coals in the Western Coal Field of Kentucky, and the two others are, at least locally, workable, one being three feet and the other four feet. These coals lie in the space from the Main Mulford coal, No. 9, to the top of the Curlew sandstone.

The Western Kentucky Coal Field can, therefore, hardly be said to have any true *Lower* Barren Coal Measures.

The lowest of the coals in this space, viz: No. 5, is, in all probability, the one at first problematically referred by M. Leo Lesquereux, to No. 2, since this is, most likely, the coal exposed on a branch in section 24, T. 3, covered with black shales, in which Mr. Cox obtained the fossil which M. Lesquereux determined to belong to the fossil species *Neuropteris tenuifolia* Brt. This coal lies some four hundred feet above the Bell coal, and at least one and a half miles east of north of Caseyville.

No. 6 is the coal usually known as the "Little Vein" of the Union county series, covered by light-buff schistose, micaceous argillaceous sandstone, with the intervention of only a few inches of somewhat darker shales, lying immediately on the coal, which latter, however, a few miles to the northwest, are thicker, and contain some curious seed vessels and imperfect shells, still undetermined.

Most of the organic remains hitherto observed in the roof of this coal are much mutilated, and difficult to refer, specifically, to their proper place, hence the paleontological evidence in regard to the geological horizon of this coal is still indefinite, but it probably represents one of the thin coals of the Barren Coal Measures of Pennsylvania, and, according to recent observations, by M. Leo Lesquereux, the Heiger's coal at Athens, Ohio.

Coal No. 7 is but a thin and rather imperfect seam, yet is of importance in a practical point of view, on account of the black band horizon which it marks. Interstratified in its shale roof is a dark, heavy calcareo-ferruginous bituminous rock, affording, locally, black band

ore. This geological level is marked, paleontologically, by the remains of fishes, some of which are very singular in their structure; but their specific character still remains undetermined. There are also marine shells in some of the layers, but those collected as yet are mostly fragmentary, amongst them is a Bellerophon, perhaps referable to *B. Mumfordiensis*.

Nothing has, as yet, been obtained from the roof of the water or well coal No. 8.

The hard black slabby shale over No. 9, or the main Mulford coal, is often vastly rich in shells, particularly a species of *Avicula*, which was at first referred to *A. papyracea*, but which is undoubtedly a distinct species, from the straightness of its sides and other characters, described in Mr. Ed. Cox's paleontological observations. It has been figured by Mr. Chappelsmith, and described by Mr. Ed. Cox under the name of *A. rectalateraria*. As yet these shales have only yielded to the paleontologist small *Calamites*, mentioned in M. Lesquereux' report. The remains of fishes are also frequent in the shales over this coal, but no marked difference has yet been observed between them and those found in a higher coal, No. 11.

It was supposed at first that No. 9 coal would prove to be the equivalent of the main Pittsburg coal, but the paleontological investigations of this have not confirmed this supposition, but rather tend to prove that it is a coal still higher in the series than the main Mulford, according to recent observations in Pennsylvania, by M. Lesquereux.

No. 10 coal that intervenes between this coal and No. 11, referred to in the former report, as the "middle coal," is not every where present in the Western coal field. It usually lies about forty to fifty feet under No. 11, and sixty to seventy feet above No. 9. Much discussion has arisen in regard to the paleontological and topographical evidence of the existence of this as a workable coal, near Providence, in Hopkins county. Not having examined the locality in person I am unable to give a decided opinion in solution of the question at issue; but, after having reviewed all the paleontological data at present collected, and the arguments in the topographical report, together with the lithological character of the specimens brought from the locality for examination my present opinion is, that when the coals about Providence are fairly opened, the coal with clay parting, under calcareous marly shale, at the

Doris Bank; the coal with clay parting under twelve to fifteen feet of limestone at the Lofland bank; and the coal with clay parting under limestone and one foot of bituminous shale, at Providence, will all be found to be one and the same coal in the horizon of No. 11, and probably, also, the coal with one or two clay partings under sixteen feet of limestone at Watson's.

The coal reported by the Topographical Assistant, with two clay partings over the twelve to fifteen feet of limestone, and covered by fifteen inches of black shale, at Lofland's, I am not prepared to place, without a personal examination on the spot; nor yet the four and a half foot coal, under four and half feet of black shale, at Thompson, reported without a clay parting. It is possible, however, that these two latter coals may prove to be No. 12 of the series, and in that case there will probably be found, in the vicinity of Providence, *three* distinct horizons of limestone, one between the Anvil sandstones and the four and a half foot coal at Thompson's; one between the two coals reported by the Topographical Assistant, at the Lofland bank, and one *under* the Watson bank; and in that case there may be also *three* distinct workable coals accessible without or with only shallow shafting, since No. 9 coal can undoubtedly be found there either above the drainage of the country, or very little below it. It should be remarked, however, that No. 12 coal, at almost every other locality where it has been opened to view, is usually composed, for two to three feet of its upper part, of a rash coal and one and a half to two feet of the bottom of a reedy coal. This lower part of No. 12 bed is an excellent coal for manufacturing iron, for which purpose it can be used, where it occurs at Airdrie, on Green river, in the raw state. At the same place this rash and reedy coal, No. 12, lies only seventeen feet above No. 11, and this is just about the distance between the two coals reported by the Topographical Assistant, at the Lofland bank, near Providence, in Hopkins county.

All these coals which have been enumerated, from No. 1 to No. 12, lie in the space between the Anvil sandstone and the conglomerate.

Where the Coal Measures are well developed—as near the valley of the Ohio river, in Union county—the space, including the above coals, from No. 1 to 12, between the top of the conglomerate and the Anvil sandstone, is about nine hundred feet. We must be prepared, how-

ever, to find this space, locally, very much reduced in thickness, especially in some portions of the margin of the basin. For instance, the paleontological evidence rather goes to show, at present, that the coal with clay pasting, sixty feet below the top of the hill below Hawesville, is the equivalent of No. 11 coal of the preceding series, and if so, the corresponding Coal Measures are reduced here, on the eastern margin of the western coal basin, to two hundred and sixty or two hundred and seventy feet; and from reports which I have seen of the coal in the townships of Wethersfield, Austin, and Canfield, in Summit and Stark counties, in Ohio, I am disposed to believe that there the same Coal Measures will be found to be contracted to nearly the same dimensions; and in some of the rich Coal Measures of Hopkins county, the thick coals lie so close together that I believe the same space will not be found to exceed more than three hundred or four hundred feet.

So far as the investigations in the Western Coal Measures have been carried, it appears that the most reliable and persistent beds of coal, lying between the conglomerate, are Nos. 1, 9 and 11.

Wherever the strata at the base of the Coal Measures are exposed in good natural sections the survey has been able to detect and recognize coal No. 1, from the Ohio river, near the mouth of Tradewater, extending back, south, with an easterly tending curvature, through Union, Hopkins, the northern confines of Christian, through Muhlenburg, into Butler. It is also recognized in Hancock in several places, generally preserving a thickness of from three to five feet. It also lies deep-seated in Henderson county, perhaps reaching a thickness of six feet or more.

No. 9 has been traced through Henderson, the greater part of Union, Hopkins, into Butler, preserving a thickness of from three to five feet. Over the same ground, No 11 usually accompanies No. 9, attaining a thickness, in Hopkins and Muhlenburg counties, of six to seven and a half feet, lying usually from eighty to one hundred feet above it.

Nos. 12, 6, 5, 4, and 3 come next in the order of persistency and reliability.

No. 12 has been observed best developed in Hopkins and Muhlenburg counties, ranging usually from two to four feet, the upper part being, however, often a "rash-coal," as already remarked.

No. 6 has been recognized, as yet, only in Union and Ohio counties.

Nos. 5, 4, and 3, only in Union county, but it is believed that in the prosecution of the survey they will be discovered elsewhere.

From sections obtained in Grundy's Ridge, and the hills back of Uniontown, together with the reports of borings made by Ruffner above the Carthage limestone; by Riddle below that rock; as well as by several borings put down in the vicinity of Uniontown, I am able now to give an approximate section of nearly five hundred and fifty feet of the Upper Coal Measures above the Anvil sandstone.

The following section exhibits the principal coals and associate strata as at present known, in connection with the measures under the Anvil sandstone, numbered and grouped in conformity with the descriptions in this volume, and with the introduction of the data and information obtained during the past two seasons.

CONNECTED SECTION OF UPPER AND LOWER COAL MEASURES OF WESTERN KENTUCKY.

Space between coal.	Feet.	Inches.	Kind of rocks.	Feet.	Inches.	
				50		Soft sandstone and shale.
					8	Thin coal, No. 18.
Space	60			50		Sandstone and shale.
				8		Carthage limestone.
				2	8	Thin coal, No. 17, of 8 inches.
				8	4	Soft shale.
Space	35	8		2	6	Sandstone.
				24	10	Soft shaly rocks and bands of sandstone.
					8	Thin coal, No. 16, and fire clay.
				3	3	

So far as these Upper Coal Measures, above the Anvil Rock, are known they contain some six or seven beds of coal, but these appear to be all thin, and it is doubtful whether there are any in Western Kentucky of workable thickness above the Anvil Rock. The two feet six inch bed is the thickest at present known. The limestone in the seventy-seven feet of space between coals Nos. 13 and 14,

CONNECTED SECTION OF COAL MEASURES.—Continued.

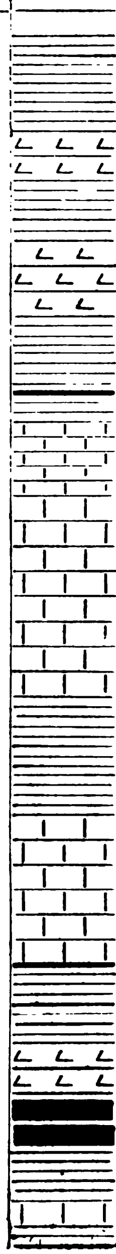
Space between coal.	Feet.	Inches.	Kind of rocks.	Feet.	Inches.	
				2		Soft and hard sandy limestone.
				10	5	Hard shaly sandstone.
Space	102			19	4	Soft slaty sandstone.
				34	2	Argillaceous shale.
				11	10	Brown shales.
					9	Hard limestone.
				1		Soft shale.
				2	6	Coal No. 15.
				4	6	Fire-clay.
				2		White limestone?
				5	10	Brown shales.
				3	11	Limestone.
				9	4	White sandy shale.
Space	115	4		50	8	White sandstone.
				38		Brown shale.
				1	1	Hard black shale.
						Coal, 1 foot, No. 14.
						One-foot fire-clay.
				7		Hard limestone.
				1	1	Hard stone.
Space	77	6		23	6	Brown shale.

probably represent the "Great Limestone" of Pennsylvania, lying between 80 and 100 feet above the Great Petersburg coal; but if so the Pittsburg coal is only represented in Union county by a thin coal.

In the shales, lying between twenty-five and fifty feet above coal No. 12, is probably the place both of the fossil stumps of trees, on Big creek, in Posey county, Indiana, and, according to recent observations by M. Leo Lesquereux, the place also of the fossil stumps of trees in the cut of the railroad, near Greensburgh.

A slight modification has been made in the thickness of the sandstone inter-

CONNECTED SECTION OF COAL MEASURES.—Continued.



Space between coal.	Feet.	Inches.	Kind of rock.	Feet.	Inches.	
				4		Dark brown shale.
				5		Black shale.
				1	6	Soft grey limestone.
				3		Hard limestone.
				4	6	Blue and light shales.
				11	9	White limestone.
				16	2	Bluish shale.
					4	Thin coal, No. 13.
				7		Fire-clay and red oxide of iron.
Space	100	2		10		Shaly sandstone.
				18	6	Hard grey sandstone.
				14	7	Soft grey sandstone.
				19	5	Bluish shale.
				7		Micaceous shale.
				12		Hard grey sandstone, Anvil Rock.
				8	8	Coarse sandstone.
				3		Hard sandstone.
					3	Thin coal of 3 inches, No. 12.
Space	21			12	8	
				8	1	Hard limestone, bituminous shale, bluish limestone, and clay.
				5		Coal, with clay parting, No. 11.
				5	6	Fire clay and pyritiferous sandstone.
Space	46			40	4	Thin bedded sandstones with harder bands intercalated.

vening between No. 7 and No. 8, from data obtained by digging a well through this space, near the mouth of Mulford's new entry. In this well they also passed through coal No. 7, which is reported two feet thick; but this probably includes some shale and black ferruginous calcareous rock, at least this is the character of that bed where it was seen in natural section, on Turkey creek, near where it empties into the Saline. The shales over coal No. 7 are often rich in carbonate of iron, and it is apparently on the same geological horizon as the black band ore of Hopkins county.

From No. 1, B, coal up to the

CONNECTED SECTION OF COAL MEASURES.—Continued.

Space between coal.	Feet.	Inches.	Kind of rock.	Feet.	Inches.	
				3		Coal, 2 to 3 feet, No. 10.
				2	6	Fire-clay and
				1	2	Shales, in all, 7 feet 8 inches.
				4		
Space	67			10		Sandstone.
				5		Shale and thin sandstone.
				5		Sandstone.
				36	4	Indurated argillaceous shale with clay ironstone basis.
				3		Avicula shale.
				5		Main Mulford coal, No. 9.
				2		Fire-clay.
				4		Shale.
				25		Sandstone and
Space	86					
				8		Shale. Coal? Shale with argillaceous iron ore.
				10		White and pink sandstone.
				2	6	Well or Water coal, No. 8.
Space	43			16		Sandstone.

top of these Upper Coal Measures, we have then about 1,350 feet. If there be, as is believed by some, from fifty to seventy-five feet more below No. 1, B, coal to the top of the Caseyville sandstone, then there would be, in all, about 1,400 feet of Coal Measures, exclusive of the conglomerate and thin coal therewith associated, to the highest point of the preceding section.

It would appear, from the foregoing section of the five hundred and fifty feet above the Anvil Rock, that we have, in this position, the only real Barren Coal Measures in the west; which affords proof that towards the termination of the

CONNECTED SECTION OF COAL MEASURES.—Continued.

Space between coal.	Feet.	Inches.	Kind of rock.	Feet.	Inches.	
				27		Sandstone.
						Shale.
				2		Coal and ferruginous limestone? No. 7.
				42		Impure limestone? and Ferruginous shales.
Space	84					
				24		Shale.
				18		Thin bedded sandstone with shale partings.
				3		Thin shale over Three Foot or "Little Coal," No. 6.
				3		Fire-clay.
Space	65			30		Soft sandstone.
				25		Micaceous sandstone.
				7		Shale with carb. of iron.
				4		Coal No. 5.
				3		Fire-clay.
				20		Dark argillaceous shale.
Space	95	3				
				42		Shale with segregations of iron stone.

carboniferous era there has been a gradual diminution in the amount of vegetable accumulation, and a gradual cessation of the condition of things favorable to the formation of thick beds of coal, with an increased quantity of calcareous material, since the limestones are evidently thicker and more frequently repeated in the measures above the Anvil Rock than below it. This, I believe, is also the case, though not in the same degree, in Pennsylvania, as the limestones appear to be more abundant in the Lower Coal Measures of that state than in the corresponding strata in western Kentucky.

Since the appearance of the

CONNECTED SECTION OF COAL MEASURES.—Continued.

Space between coal.	Feet.	Inches.	Kind of rock.	Feet.	Inches.	
				20		Massive Curlew sandstone.
				1	3	
				4		
				5		Shale.
				4		Curlew coal, with two shale partings, No. 4.
				15		Shale,
				4		Curlew limestone.
						Shale.
						Coal?
Space	147			62		Shale.
				10		Sandstone.
				15		Shale with thin coal.
				10		Sandstone.
				12		Shale.
				1	3	Coal.
				3	6	Shale with ironstone.
				2		Band of sandstone.
				10		Shale, with carbonate of iron.
				2	6	Ice-house coal, No. 3.
				1	3	
				10	4	Soft brown sandstone.
				40		Massive ferruginous and carbonaceous sandstone of the "Finnie Bluff."
Space	154					
				6 1 4 10		Shale and thin bedded sandstone.
						Thin coal, No. 2.
				15		Shale.
				10		Sandstone.
				6	6	Shale.

First Report, the completion of the Airdrie shaft has afforded an excellent opportunity of observing the modifications which the Coal Measures have undergone in the valley of Green river, for four hundred feet below No. 12 coal.

The shale over No. 12 coal here includes a bed of excellent black band iron ore, six to seven inches in thickness. Coal No. 12 is here composed of two to three feet of rash coal above, with twenty inches of reedy coal below, which has the valuable property of being suitable for the reduction of the black band iron ore in its raw condition without coking.

At twenty-one

CONNECTED SECTION OF COAL MEASURES.—Continued.

Space between coal.	Feet.	Inches.	Kind of rock.	Inches.	Inches.	
				50		Thin bedded sandstone with shale partings.
						"Grey metal."
				4		Bell coal, No. 1, B.

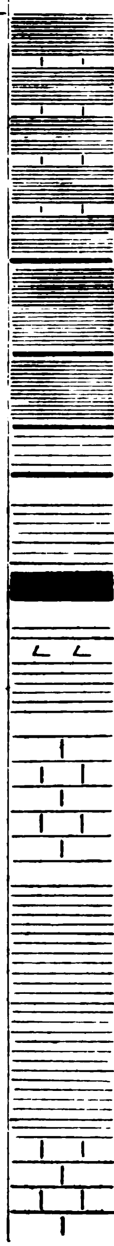
SECTION IN THE AIRDRIE SHAFT, GREEN RIVER.

Space between coal.	Feet.	Inches.	Kind of rock.	Feet.	Inches.	
				50		Sandstone and shale.
					7	Good black band iron ore.
				4	6	Coal rash and coal No. 12.
Space	21			17		Shale.
				4		Limestone.
				6		McLean coal No. 11.
Space	84			72		Fine freestone for building purposes. No. 10 coal wanting.
				12		Shale.
				5		Splint coal No. 9.

feet below this coal comes in the Main Airdrie six feet coal, overlaid by limestone, formerly known under the name of the McLean coal. At eighty-four feet below this a five-foot coal, No. 9, occurs, the space being somewhat diminished from what it is in Union county, and filled mostly with the freestone which has been employed in the construction of the splendid Airdrie Furnace. This is an excellent and a beautiful building material. No. 10 coal does not appear to exist here.

At sixty-two feet below No. 9 coal, there is a thin coal, which no doubt is the same as the thin coal quarried at thirty feet above

SECTION OF AIRDRIE SHAFT.—Continued.



Space between coal.	Feet.	Inches.	Kind of rock.	Feet.	Inches.	
				61		Shale and sandstone.
					4	Thin coal.
				39	6	Shale.
					6	Thin coal No. 8?
				2		Black shale.
Space	100	6		16	3	Shale.
					3	Thin coal.
				7	1	Blue and grey shale.
				1		Thin coal.
						Fire-clay.
				9	2	Shale.
				2		Coal No. 7?
				1		Fire-clay.
				3	10	Impure limestone.
				6	7	Fire-clay.
				4	4	Bluish sandstone "*Fakes.*"
Space	35	9		28	5	Hard sandstone.
				4	4	Sh. mic. sandstone "*Fakes.*"
				10	3	Sch. sandstone, "*sandy blaze.*"
				2	9	"*Fakes.*"
				3	1	"*Sandy blaze.*"
				2	11	Fakes.
				8	6	"Blaze."
					10	Hard flagstone.
				17	4	Sch. sandstone or blaze.
				2	4	Black shale.
				2	11	Blaze.
Space	134	5		3	2	Slaty rock.
				4	1	Sandstone.
				14	8	Hard sandstone.

No. 8 coal, in Union county. The space from No. 9 coal, to the six-inch coal, which is probably equivalent to No. 8 coal, of the Union county section, is exactly one hundred feet. In the space beneath No. 8 coal there are two thin coals before reaching what appears to be No. 7 coal, of which we have no account in Union county, but the one is only one inch thick, and the other one foot. The space between No. 6 and No. 7 coals has increased greatly in thickness by the swelling up of the shaly strata, while No. 6 coal has thinned out. The succeeding space between No. 5 and No. 6 coal differs only elev-

SECTION OF AIRDRIE SHAFT.—Continued.

Space between coal.	Feet	Inches.	Kind of rock.	Feet.	Inches.	
				7	1	Sandy blaze.
						Thin coal No. 6.
				6	10	Fire clay.
				18	6	Hard sandstone.
				6	7	Blaze.
Space	71	2		3		Sandstone.
				1	2	Blaze.
				6		Schistose sandstone.
				9		Sandstone.
				8	2	Blaze.
				1	6	Impure limestone and
					4	Iron Balls.
					5	Hard sandstone.
				9	9	Blaze.
					9	Ironstone balls.
				3	6	Coal No. 5?
				1	4	

en feet from what it is in Union county, by the interpolation of some shaly matter amongst the sandstone. No. 5 coal is about six inches thinner than in Union county. In comparing these two last spaces with the corresponding space of one hundred and ninety-six feet, in the Holloway borings, composed of alternations of sandstone and shale, it will be found that it is only eleven feet greater. All this proves that while the space between No. 9 and No. 11 coal has been diminishing slightly towards the east, the space between No. 5 and No. 7 coal has been at the same time increasing.

If we may judge from what is known now of our Western Coal Measures, we are led to the conclusion, that where the spaces between the coals are greatest the coals themselves are, as a general rule, thinnest, especially when these spaces are mostly filled with shale, and *vice versa;* the inference deducible from this phenomenon is, that where the elevations and depressions of the earth's surface, during the carboniferous era, have been greatest, thus forming deep depressions for the accumulation of fine sedimentary matter, less time has elapsed for the accumulation of the peculiar vegetation which went to form the coal, because those portions of the areas of the Western Coal Basin have been, for longer periods, submerged.

EASTERN COAL FIELD.

Since the preceding Report went to press, all the remaining counties, not previously visited, have received a general reconnoisance.

During that exploration the extension of the margin of the Eastern Coal Measures was examined through Rowan, Bath, Powell, Estill, and Madison, and the southern part of Morgan counties. In this place I shall define its boundaries approximately. Passing through Rowan county, in a south-east course, up the Christie branch of Triplett creek, the sub-carboniferous limestone is first encountered, near Kirk's Mill; and near the head of the same branch the first coal comes in, but the outcrops which I examined only indicate a thin coal as the first in the series on these waters of Triplett creek, as well as on the head of Tygert's creek, near the line between Carter and Rowan counties. The lower coal shows itself, also, on Crany creek which empties into the north fork of the Licking, where it is said to be sixteen inches thick. The conglomerate was first observed in a branch below John Nichol's house, and is well developed at the crossing of the north fork of the Licking, on the road from Nichol's to West Liberty.

The boundary of the coal formation crosses the Licking not far from Gill's Mill, extending thence towards the head waters of Clear creek, in Bath. In this direction the first coal in the series thickens, and becomes a workable coal in Bath. The first bed lies here only fifteen feet above the top of the sub-carboniferous limestone, and about sixty feet under the base of the high cliffs of conglomerate. It has a clay parting of one foot: the upper member of the coal being one foot ten to two feet thick; the lower member, probably a foot in thickness, as near as I was able to ascertain, making in all about three feet of good coal.

This is the nearest workable coal to the line of the Lexington and Big Sandy railroad that I have seen, until the line of that road crosses Tygert's creek. In Bath county this bed of coal is within six miles, in a direct line, of the route surveyed northwest of the Olympian Springs; the other line, which has been proposed, south of those springs, would be little over three miles distant. Taken in connection with the other mineral resources of Bath county, this fact is of great importance, in considering the accessibility to market of the mineral wealth of this part of Kentucky. Elsewhere, under the head of Bath county, will be found further particulars descriptive of the stratagraphical geology of that county.

From the head of Clear creek the boundary of the Coal Measures extends to the head of Stone-quarry creek, the heads of the eastern branches of Beaver, thence on to the head of Indian cree near the

confines of Bath and Powell counties. On the waters of this latter stream the lowest coal has been fairly opened, by Morris McCormick, mined to some extent, and hauled to Mt. Sterling, where it is already in general use as fuel. McCormick's coal lies just fifteen feet above the sub-carboniferous limestone, and about seventy feet under the high vertical escarpments of conglomerate that form the water shed between Red River, of the Kentucky, and Beaver creek, of the Licking. I had here a better opportunity of getting an exact measurement of the low coal of this part of the eastern Coal Measures than at any other point, as the bed is fairly opened from its floor to the roof. The exact thickness is two feet nine inches The floor is a dark, gritty, indurated shale, or impure fire clay; the roof, dark-grey shale, containing long, slender, pointed, leaf-like impressions, probably the "needle leaves" (Lepidophyllum?) of the Lepidodendron, coming off from the terminating branches that support the *Lepidostrobus*.

From Indian creek, the boundary of the Coal Measures bears through the south-eastern part of Powell to the Chimney Top, and on to Cow creek, one of the southern tributaries of Red River, where the lowest bed of coal has been worked, to some extent, for the use of the Red River Forge and Rolling Mill, and may be, from the best information at present in my possession, of corresponding thickness. Thence it extends through Estill county to the head of Miller's and Cow creek, both independent tributaries of the Kentucky river, reaching here in Estill, to within five miles of Irvine.

Though the sub-carboniferous limestone, marking the base of the Coal Measures, appears above the waters of Kentucky river, even a short distance above the mouth of Contrary creek in Owsley county, yet the overlying low coal, and overlying conglomerate, continue to cap the high hills bordering on the Kentucky river, even as low down as Buck creek in Estill county. These high ranges of conglomerate, with its subordinate low coal, range from thence nearly south, towards the more westerly course of the "Big Hill Range," in the south-east corner of Madison county; broken through, however, by the gorges, and gaps, giving passage to the different branches of Station Camp creek; here they again take a more southerly direction to connect with the limits of the Coal Measures, previously noted in the First Report, on the heads of Roundstone and Lick Fork of Laurel, in Rockcastle county.

This gives a very correct *general* view of the north east limit of the Coal Measure, from the borders of Carter county at the heads of Triplett and Tygert's creek, through Rowan, Bath, Powell, Estill, and Madison counties, but, since it coincides with the course of certain mountain ranges, it cannot be laid down precisely, in all its meanders, until the topography of these hills has been surveyed, and plotted on maps of a sufficient scale.

The lowest coal, lying between the base of the conglomerate and the sub-carboniferous limestone, will probably be found of workable thickness along the greater part of its range through Rowan, Bath, Estill, and Madison counties. Its place can generally easily be discovered by the coal dirt, streaks of fire-clay, or springs of water, that appear some fifteen or twenty feet above the top surface of the sub-carboniferous limestone. Throughout the same extent of country, there will usually be found a valuable bed of iron ore of the limonite and carbonate varieties, reposing immediately on the upper surface of the sub-carboniferous limestone, conforming with its elevations and depressions; in this respect, differing entirely in its position from the deposites of hematitic and hydrated oxides, which have been described in the First Report, occuring associated with the sub-carboniferous limestone, in the western counties, near the Cumberland river.

The Coal Measures, in Morgan county, have been further explored, since the appearance of the first volume, especially on the Elk, Caney, and main fork of the Licking, as high as West Liberty. The most interesting features in the geology of this part of the country are the numerous outcrops of Cannel coal. The main bed lies towards the base of the hills, and sometimes, immediately in the channel of the stream, and is composed almost entirely of this variety of coal, which varies from thirty to fifty inches in thickness. There is another bed, the upper fourteen inches of which is also cannel coal. This bed lies, usually, high in the hills, some three hundred feet above the main cannel bed. It is probable that this high bed of coal may prove to be the equivalent of No. 11 coal of the Western Coal field.

If we may judge from the character of the contorted sandstone with lenticular masses and imperfect seams of coal, that underlie the low main coal of Morgan county, and from the two other beds of coal that underlie that mass of sandstone, before reaching any conglomerate, we should be disposed, at present, to place this coal as the equiv-

alent of No. 3, of the Western section, though that coal appears to be the equivalent of the Lower Freeport coal D, of Leslie's section; one coal higher in the series than the great repository of cannel coal of Pennsylvania. This Morgan county cannel coal bed is full of the remains of stigmaria, so frequently met with in beds of cannel coal. We are, however, as yet not in possession of sufficient paleontological evidence to be able to speak, with entire confidence, in regard to the equivalency of the main cannel bed of Morgan county.

The reader is referred, for further information in regard to this portion of the eastern coal field, to the sequel of this report, under the head of Morgan county.

The same, or a similar coal series exists in Breathitt county, where outcrops of cannel coal are equally abundant, especially on the waters of Troublesome creek, not far from the Kentucky river.

CHAPTER II.

AGRICULTURAL GEOLOGY.

KENTUCKY SOILS.

Through the systematic industry and untiring perseverance of the Chemical Assistant, Dr. Robert Peter, I am able to present the detailed analyses of no less than one hundred and thirty-eight soils, subsoils, under-clays, and marly earths, in addition to the twenty-one, which appeared in the first volume, and the forty-three, in the second volume, making in all two hundred and two. Of these eleven are derived from the quaternary deposits; seventeen from the Coal Measures; thirty-seven from the sub-carboniferous group; four from rocks of Devonian date; eighteen from rocks of Upper Silurian date; and one hundred and thirteen from rocks of Lower Silurian date, or from the so-called blue-limestone formation of Kentucky.

Besides the detailed statements comprised in the body of the Chemical Report, they have been tabulated at the close of Dr. Peter's report, arranged in the *alphabetical* order of the counties, for easy reference. At the close of this chapter, they will be found, also tabulated and arranged by the *formations*, from which they were derived, showing, at the same time, the nearest underlying member, over which they were collected; to enable the reader to observe, at a glance, the chemical peculiarities, so evidently imparted to the soil, by the subjacent rock formation.

The superiority of the soils, derived from the strata belonging to our blue limestone formation, becomes then clearly apparent, and this fact, in agricultural chemistry, may be safely laid down as well established, that *the more replete the rock has been with fossil organic relics, and the more earthy and easy of decomposition the calcareous rock, the more productive the soil derived therefrom.*

Of all the Kentucky soils examined, up to the present time, those which result most immediately from the disintegration of the coralline and shell beds of the blue-limestone formation of Central Kentucky are decidedly the most fertile. I would particularly cite, in illustration of this fact, soil No. 550, in Woodford county; Nos. 568 and 574, from Bourbon; No. 27, in Fayette; No. 580, of Boyle; Nos. 603 and

612, of Franklin; No. 619, from Gallatin county; No. 621, from Garrard county; No. 649, from Henry county; No. 681, from Mercer county; Nos. 741, 720, and 724, from Nelson county; No. 748, from Scott; No. 755, from Shelby; No. 758, from Spencer; Nos. 770 and 773, from Washington county; all of which soils I found reposing almost immediately over the *Chætetes*, *Leptæna lynx*, *Orthis*, and other highly fossiliferous and more or less earthy coralline and shell beds of the blue-limestone.

I also desire, in this connection, to call the attention of the agricultural community, of these counties, to the very important practical fact deduced from the chemical examinations, that the sub-soil and especially the red under-clays and shell earths, are often richer in the true elements of fertility, than even the virgin soil itself, and therefore afford, by far, the cheapest, and most accessible source whence mineral manures, for the restoration of their soils, can be obtained. Witness Nos. 552 and 553, in Woodford; Nos. 570 and 571, in Bourbon; Nos. 509 and 510, in Fayette; Nos. 608 and 614, in Franklin; No. 623, from Garrard; No. 651, in Henry county; No. 680, in Mercer; Nos. 717, 718, 722, and 723, in Nelson; No. 757, in Shelby; and No. 775, in Washington counties. The under-shell earth of the blue-ash lands of Nelson, No. 723; the loose friable under earth, No. 717, in the same county; the under clay, No. 684, of Mercer; the sub-soil, No. 683, of the same county; the sub-soil, No. 623, of Garrard; the sub-soil, No. 620, of Gallatin; the sub-soil, No. 252, of Woodford; the red under-clay, No. 509, of Fayette; the red shell under-earth, No. 571, of Bourbon; the sub-soil, No. 567, of Boone; are truly remarkable for the extraordinary amount of the mineral fertilizers which enter into their composition, and contain stores of agricultural wealth which cannot be over-estimated.

The poorest soils, which have been yet examined, derived from rocks of Lower Silurian date, are those that immediately over-lie the upper beds of the Kentucky river marble. The reason of this is evident; it is a compact, close-textured, hard, brittle limestone of difficult decomposition, not by any means fossiliferous, and often cherty, with very little marly or argillaceous partings in its bedding. This formation seldom reaches the surface near enough to impart character to the soil, so that there is but a very limited area in Kentucky, where the soil can be said to be characteristic of that rock formation.

The soil derived from the silicious mudstones, when not interstratified with fossiliferous limestones, are also inferior in fertility to the generality of the blue limestone soils, though often well adapted, for a few years, to the growth of fine, silky, tobacco.

The best soil derived from rocks of Upper Silurian date, as far as the analyses of Kentucky soils have yet been carried, are those derived from the Favistella beds, which lie at the base of this group, adjacent to the upper beds of the blue limestone, and the cellular magnesian limestones, and Calymene magnesian limestones, viz: No. 522, from Jefferson county; No. 734, from Oldham county; No. 719, from Nelson county. No. 525, of Jefferson county, remains, as yet, the richest under-clay, from rocks of Upper Silurian date, that has been analyzed, up to the present time, and contains, in fact, a much larger proportion of mineral fertilizers than any of the soils analyzed from this formation.

Of the few soils, yet to be examined, derived from rocks of Devonian date, those super-imposed on the encrinital beds are the best. Those derived from the black shale are nearly as rich in the mineral fertilizers; indeed they contain more of the alkalies, potash and soda, only they are soils more difficult to subdue, and require thorough draining in order to yield well. This season, in Estill county, an excellent crop of corn was observed growing near Irvine, in a peculiar variety of the black slate, only very partially disintegrated into soil, so that large slabs of the slate lay still scattered over the surface of the ground. The most productive soil, yet analyzed, from the sub-carboniferous formation, is No. 461, from Hardin county, collected on the slope of the knobs under the encrinital beds of the lower part of this group. It owes its superiority, no doubt, to the washings received from the encrinital limestones.

The poorest soil, yet examined, is No. 642, collected on the top of the Salt river knobs, in Hardin county, over the knob freestone, of the lower division, of the sub-carboniferous group.

Soils No. 20, from Christian county; No. 161, from Simpson county; No. 163, from Todd county; and No. 225, from Barren county, all derived from the cavernous beds of the sub-carboniferous limestone group, are amongst the best soils from this formation. The cavernous nature of these rocks is proof of their proneness to disintegrate, by degrees, subject to the influence of carbonated waters and atmospheric

agencies, but still not with the same rapidity as the more earthy blue limestones and marlites of the Lower Silurian Period, and being far less fossiliferous than these rocks, they only contain about half as much phosphoric acid as the average of the blue limestone soil, and one third as much alkalies. For the same reason, the red under-clays and sub-soils of this formation—for instance, No. 216, from Christian county; No. 217, from Logan; and No. 480, from Simpson—though richer in phosphoric acid and alkalies than the overlying virgin soil, still cannot compare in the total amount of these elements of fertility with the red under-clays, earth, and subsoils, of the blue limestone formation.

Amongst the Coal Measure soils, now analyzed—if we except the bottom land soils of Union county, No. 237 and 767—those from Hancock county, No. 636; from Daviess, No. 597; and from Laurel No. 224, have turned out the best. No. 597 is considered one of the best tobacco soils of Daviess county; it contains the largest amount of organic and volatile matters and hygrometric moisture; it stands third in the list of Coal Measure soils, for the amount of soluble extract obtained by digestion with carbonic acid water, and the quantity of carbonate of lime; third in the list for the amount of phosphoric acid; fifth in the list for the amount of potash, with about an average quantity of soda.

The Henderson county fine tobacco soil, No. 126, stands prominent amongst quaternary soils for the large amount of saline matter, soluble in carbonic acid water; and in the two hundred and two soils examined, up to this time, it is only exceeded, in this respect, by two from the blue limestone formation, No. 665, from Jessamine county, and No. 621, from Garrard county. It contains about an average quantity of phosphoric acid, but less potash than might have been expected. This may perhaps be accounted for from the fact that it was taken from a field which has been some years in cultivation, and had a crop ef tobacco on it at the time the soil was collected. Sub-soil, No. 218, from Ballard county, contains as yet the largest quantity of phosphoric acid obtained from any of the quaternary soils—no doubt due to the number of shells belonging to the genera *Helix*, *Helicina*, *Cyclostema*, *Succinia*, *Pupa*, *Cyclas*, *Planorbis*, and *Lymnia*, which occur in the silico-calcareous earth, or shell marl, No. 339, of the State

collection which forms the sub-stratum both in Ballard and Hickman counties.

By consulting Dr. Peter's report it will be observed that, with very few exceptions, the comparative examination of the virgin soil and the soil from an adjacent old field, the loss which the cultivated soil has sustained by the removal of the incombustible mineral fertilizers has been clearly indicated by the chemical analysis, conducted with the necessary precautions mentioned by Dr. Peter in his prefatory remarks. The few exceptions have, for the most part, occurred in agricultural districts, where the rocks, rich in phosphoric acid, lime and alkalies, decompose with remarkable facility and supply the removed ingredients almost as fast they are assimulated. This is the case, in part of Henry county, where soils, No. 649 and 650, were collected, which specimens form one of the most remarkable exceptions, of the soil of the old field exhibiting, by chemical analysis, more of the principal fertilizers than the virgin soil. In this case no virgin soil could be obtained, on exactly the same level. The strata of the blue limestone are here not only thin bedded but of a marly nature, disintegrating with great facility and some of the layers, lying only a few feet apart, are much more fossiliferous than others, I have little doubt therefore that, in this particular instance, the soil of the old field was, originally, much stronger than the virgin soil collected.

Some such exception must have operated in the case of soils Nos. 662 and 663, though the immediate cause, at the locality where they were collected, is not so apparent.

For further details in regard to the analyses of these soils, I must refer you to Dr. Peter's report, where much valuable information will be found, and good counsel given, as well for the renovation of impoverished land, as for the applications required to soils deficient in one, or more of the mineral fertilizers.

In presenting these chemico-agricultural results to the farming community of the commonwealth of Kentucky, I cannot help believing that, while they form one of the most valuable contributions which the united labors of the geologist and chemist have ever presented to agriculture, they must advance the science of agricultural chemistry, and supply hints to the agriculturalist, and owners of landed estates, of the highest practical importance, and they must, at the same time, impress the public, generally, most forcibly, with the ex-

traordinary fertility of a very large portion of the area of Kentucky, especially that based on the blue limestone formation, most of the soils of which compare favorably with the richest lands on the face of the earth, and surpass, in the elements of permanent fertility, the far famed prairie lands of the west, except where these prairie-soils are based on the same description of highly fossiliferous limestones, and marly earths and calcareous clays.

The chemical analysis of the soils derived from the silicious mudstones and shales belonging to the Lower Silurian period, as well as of the rocks themselves, and the waters flowing through or over them, all indicate a proponderance of magnesia, especially in these regions where the milk-sickness has been most prevalent. It has not been determined yet whether this magnesia is not, in part, combined with chlorine, to form chloride of magnesium, but the excess of magnesia, together with the excessive solubility of this salt, leads me to suspect that it does; if so, it may account, in part, for the peculiar forms of disease which exist where these rocks and soils are in greatest force, for reasons which I have elsewhere touched on in speaking of the therapeutic effects of chloride of magnesium, the "bitter water" of the salt boiler.

TABLE A.

Soils, Sub-soils, and Under-clays derived from deposites of Quaternary date.

Number in the report.	County.	Dissolved from 1000 grains by water containing carb. acid.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soil. Remarks, &c.
1	Ballard,	1.530	1.84	3.040	3.93		0.411	0.034	0.461	0.116	not det.	not det.	0.108	0.037	92.01	Silico-calc. loam No. 339.
218	Ballard,	0.733	1.80	2.110	2.580	2.240	0.090	0.150	0.860	0.410	do.	do.	0.120	0.020	91.72	Sub soil, No. 339.
2	Ballard,	1.943	2.44	4.12	4.85		0.081	0.134	0.280	0.155	do.	do.	0.139	0.063	89.65	Soil.
219	Ballard,	1.293	2.14	2.92	2.250	3.390	0.360	trace.	0.470	0.180	do.	do.	0.190	trace.	90.21	Sub-soil.
29	Fulton,	1.115	1.72	1.72	4.47		0.036	1.540	0.517	0.102	do.	do.	0 108	0.052	92 35	Sub-soil.
30	Fulton,	1.275	3.80	2.60	9.51		-	0.393	0.503	0.157	do.	do.	0.170	0.82	87.03	Under the gravel bed, but derive dprobably mostly from No. 339.
126	Henderson,	7.043	2.04	5.08	3.49		-	1.254	0.447	0.129	do.	do.	0.085	0.034	89.67	Mostly from No. 339.
127	Fulton,	-	1.60	-		3.69		0.900	4.350	-	do.	do.	0.070	0.020	90.99	White earth under No. 339.
128	Hickman,	0.270	2.30	2.00	6.00		0.170	1.150	0.160	0.129	do.	do.	0.170	0.200	90.57	Soil from No. 129.
129	Hickman,	-	5.00	4.80	8.65		trace.	1.250	0.260	-	do.	do.	0.520	0.300	84.04	White earth under No. 339.
230	Daviess,	3.592	1.62	3.350	2.026	2.146	0.126	0.176	0.258	0.088	do.	do.	0.096	0.053	91.92	Mostly derived from quaternary, No. 339.

TABLE B.

Soils, Sub-soils, and Under-clays derived from rocks of the Coal Measures.

Number in the report.	County.	Dissolved from 1000 grains by water containing carb. acid.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soils. Remarks, &c.
10	Butler,	1.884	1.86	3.460	5.03		0.025	0.097	0.305	0.076	not det.	not det.	0.204	0.074	90.59	Soil from a ridge.
138	Hopkins,	-	1.88	3.880	6.15		trace.	0.060	0.210	0.089	do.	do.	0.100	0.060	89.19	In the heart of the Coal Measures near Capt. Davis' coal mine.
155	Muhlenburg,	7.780	2.85	5.800	5.05		0.310	1.070	0.540	0.090	do.	do.	0.190	0.030	86.64	N. slope in N. part of Co.
224	Laurel,	2.404	3.60	6.190	8.926	0.078	-	0.116	0.280	0.139	0.355	0.009	0.239	0.021	83.626	Soil from argillaceous shales and soft sandstone at base.
233	Ohio,	2.330	1.74	5.080	4.349		-	0.176	.166	0.101	0.413	0.066	0.157	0.015	90.166	Upper beds.
237	Union,	2.280	2.76	1.580	2.986	2.666	0.056	0.396	0.390	0.115	-	0.003	.139	.116	88.426	Black bottom land of Pond creek.
235	Union,	1.480	3.16	2.740	9.530		-	0.276	0.287	0.147	0.288	-	.185	.056	86.130	Sub-soil ¼ m. from Pond creek.
236	Union,	1.920	3.54	3.670	2.230	5.080	0.080	0.136	0.633	0.088	.466	0.003	.087	.062	87.250	Soil from post oak glades on sandy shales, middle beds.
597	Daviess,	4.433	4.20	6.972	1.360	1.660	0.218	0.536	0.358	0.177	.103	-	.193	.029	88.294	Tobacco soil sandy shales over coal No. 9?
598	Daviess,	3.720	2.88	6.301	1.776	2.380	0.038	.416	.341	.151	.095	-	.158	.027	89.236	Tobacco soil from field four years in tobacco and wheat.
599	Daviess,	1.587	2.400	2.868	1.756	2.520	0.174	.038	.156	.177	.068	-	.097	.015	92.276	Sub-soil from same field.
636	Hancock,	4.890	3.325	6.022	2.295	2.390	.145	.310	.334	.196	.096	-	.250	.054	87.910	Soil from lower sandstones and shales.
637	Hancock,	1.820	3.415	2.883	2.120	2.430	.260	.240	.278	.063	.067	-	.174	.066	91.070	Soil from old field 26 years in cultivation.
638	Hancock,	1.128	3.175	3.020	4.190	4.865	.070	.130	.605	.107	.101	-	.219	.055	86.645	Sub-soil from same field.
767	Union,	1.928	3.50	3.720	3.465	2.920	.950	.624	.630	.196	.067	-	.133	.104	87.510	Creek bottom.

769	Union,	0.866	3.50	3.333	4.290	5.365	.495	trace.	.541	.162	.076	-	.231	.111	85.330	Silicious shales from post oak flats.
231	Whitley,	2.222	3.28	6.300	5.270	5.660	.121	.076	.420	.165	.322	-	.170	.147	80.786	Ferruginous shales.

TABLE C.

Soils, Sub-soils, Under-clays, and Marls derived from rocks of Sub-carboniferous group.

Number in report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture.	Organic & volatile matters.	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately underlying the soils. Remarks &c.
90	Christian,	3.822	2.60	5.68	5.47		0.415	0.220	0.280	0.129	0.09	not det.	0.154	0.061	87.43	Soils from cavern. beds.
216	Christian,	.960	2.24	2.96	2.390	2.360	.270	.130	.790	.270	not det.	do.	.190	.04	90.26	Sub soil from cav. beds.
140	Livingston,	.453	3.76	3.24	9.77		.400	.370	.405	.064	-	-	.108	.200	85.83	Soil from the iron region.
141	Logan,	1.390	2.30	3.50	5.16		.119	.196	.118	.076	-	-	.181	.171	90.06	Soil from cavern. beds.
217	Logan,	0.585	2.80	3.14	4.770	3.660	.106	.300	.400	.140	-	-	.120	.030	89.27	Sub soil from cav. beds.
161	Simpson,	2.946	2.80	5.10	6.51		.235	1.940	.235	.129	-	-	.131	.070	87.47	Soil from cavern. beds.
480	Simpson,	.608	4.14	7.02	11.980	8.820	.130	.210	.200	.240	-	-	.190	.060	71.13	Red sub-soil from cav. beds.
163	Todd,	1.693	2.80	4.18	6.83		.114	.194	.475	.156	-	-	.178	.095	87.83	Soil from cavern. beds.
162	Todd,	-	2.00	4.10	4.10		-	1.420	.240	.062	-	-	.110	.030	88.30	Sub soil from cav. beds.
165	Trigg,	1.043	1.74	3.28	3.69		.195	.034	.195	.063	-	-	.096	.022	92.31	Soil from barren oak land 4 m. N. of Cadiz, cherty beds.
168	Warren,	1.042	2.18	2.90	5.129		.054	.940	.350	.076	-	-	.150	.043	90.99	Soil from geodifer. beds.
233	Adair,	2.471	2.50	4.440	4.841		-	.196	.046	.065	0.232	.005	.075	.092	90.416	Soil from dark shaly geodiferous beds.

TABLE B.

Soils, Sub-soils, and Under-clays derived from rocks of the Coal Measures.

Number in the report.	County.	Dissolved from 1000 grains by water containing carb. acid.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soils. Remarks, &c.
10	Butler,	1.884	1.86	3.460	5.03		0.025	0.097	0.305	0.076	not det.	not det.	0.204	0.074	90.59	Soil from a ridge.
138	Hopkins,	-	1.88	3.880	6.15		trace.	0.060	0.210	0.089	do.	do.	0.100	0.060	89.19	In the heart of the Coal Measures near Capt. Davis' coal mine.
155	Muhlenburg,	7.780	2.85	5.800	5.05		0.310	1.070	0.540	0.090	do.	do.	0.190	0.030	86.64	N. slope in N. part of Co.
224	Laurel,	2.404	3.60	6.190	8.926	0.078	-	0.116	0.280	0.139	0.355	0.009	0.239	0.021	83.626	Soil from argillaceous shales and soft sandstone at base.
233	Ohio,	2.330	1.74	5.080	4.349		-	0.176	.166	0.101	0.413	0.066	0.157	0.015	90.166	Upper beds.
237	Union,	2.280	2.76	1.580	2.986	2.666	0.056	0.396	0.390	0.115	-	0.003	.139	.116	88.426	Black bottom land of Pond creek.
235	Union,	1.480	3.16	2.740	9.530		-	0.276	0.287	0.147	0.288	-	.185	.056	86.130	Sub-soil ¼ m. from Pond creek.
236	Union,	1.920	3.54	3.670	2.230	5.080	0.080	0.136	0.633	0.088	.466	0.003	.087	.062	87.250	Soil from post oak glades on sandy shales, middle beds.
597	Daviess,	4.433	4.20	6.972	1.360	1.660	0.218	0.536	0.358	0.177	.103	-	.193	.029	88.294	Tobacco soil sandy shales over coal No. 9?
598	Daviess,	3.720	2.88	6.301	1.776	2.380	0.038	.416	.341	.151	.095	-	.158	.027	89.236	Tobacco soil from field four years in tobacco and wheat.
599	Daviess,	1.587	2.400	2.868	1.756	2.520	0.174	.038	.156	.177	.068	-	.097	.015	92.276	Sub-soil from same field.
636	Hancock,	4.890	3.325	6.022	2.295	2.390	.145	.310	.334	.196	.096	-	.250	.054	87.910	Soil from lower sandstones and shales.
637	Hancock,	1.820	3.415	2.883	2.120	2.430	.260	.240	.278	.063	.067	-	.174	.066	91.070	Soil from old field 26 years in cultivation.
638	Hancock,	1.128	3.175	3.020	4.190	4.865	.070	.130	.605	.107	.101	-	.219	.055	86.645	Sub-soil from same field.
767	Union,	1.928	3.50	3.720	3.465	2.920	.950	.624	.630	.196	.067	-	.133	.104	87.510	Creek bottom.

769	Union,	0.866	3.50	3.333	4.290	5.365	.495	trace.	.541	.162	.076	-	.231	.111	85.330	Silicious shales from post oak flats.
231	Whitley,	2.222	3.28	6.300	5.270	5.660	.121	.076	.420	.165	.322	-	.170	.147	80.786	Ferruginous shales.

TABLE C.

Soils, Sub-soils, Under-clays, and Marls derived from rocks of Sub-carboniferous group.

Number in report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture.	Organic & volatile matters.	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately underlying the soils. Remarks &c.
90	Christian,	3.822	2.60	5.68	5.47		0.415	0.220	0.280	0.129	0.09	not det.	0.154	0.061	87.43	Soils from cavern. beds.
216	Christian,	.960	2.24	2.96	2.390	2.360	.270	.130	.790	.270	not det.	do.	.190	.04	90.26	Sub soil from cav. beds.
140	Livingston,	.453	3.76	3.24	9.77		.400	.370	.405	.064	-	-	.108	.200	85.83	Soil from the iron region.
141	Logan,	1.390	2.30	3.50	5.16		.119	.196	.118	.076	-	-	.181	.171	90.06	Soil from cavern. beds.
217	Logan,	0.585	2.80	3.14	4.770	3.660	.106	.300	.400	.140	-	-	.120	.030	89.27	Sub soil from cav. beds.
161	Simpson,	2.946	2.80	5.10	6.51		.235	1.940	.235	.129	-	-	.131	.070	87.47	Soil from cavern. beds.
480	Simpson,	.608	4.14	7.02	11.980	8.820	.130	.210	.200	.240	-	-	.190	.060	71.13	Red sub-soil from cav. beds.
163	Todd,	1.693	2.80	4.18	6.83		.114	.194	.475	.156	-	-	.178	.095	87.83	Soil from cavern. beds.
162	Todd,	-	2.00	4.10	4.10		-	1.420	.240	.062	-	-	.110	.030	88.30	Sub soil from cav. beds.
165	Trigg,	1.043	1.74	3.28	3.69		.195	.034	.195	.063	-	-	.096	.022	92.31	Soil from barren oak land 4 m. N. of Cadiz, cherty beds.
168	Warren,	1.042	2.18	2.90	5.129		.054	.940	.350	.076	-	-	.150	.043	90.99	Soil from geodifer. beds.
233	Adair,	2.471	2.50	4.440	4.841		-	.196	.046	.065	0.232	.005	.075	.092	90.416	Soil from dark shaly geodiferous beds.

TABLE C—Continued.

Number in the report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture.	Organic & volatile matters.	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soil. Remarks, &c.
225	Barren.	3.872	2.34	5.200	3.460	2.206	.234	.366	.205	.159	.197	-	.197	.090	87.686	Soil from lithostrotion and cherty beds.
227	Barren.	0.820	3.90	4.730	10.380	6.398	.256	.096	.522	.075	.466	-	.142	.082	77.067	Sub soil from lithostrotion and cherty beds.
312	Breckinridge,	1.775	6.72	7.040	12.170		-	.976	.413	.101	.198	·002	.556	.190	78.680	Marly shale under Archimedes beds.
222	Clinton,	1.461	1.96	3.970	1.766	2.466	.076	.076	.131	.090	not det.	not det.	.065	.099	90.720	Upper beds near junction with millstone grit.
232	Cumberland,	5.122	2.40	5.770	1.230	3.140	.076	.336	.438	.127	.734	.006	.220	.029	87.110	Knob formation near junction with black slate.
228	Monroe,	2.853	1.82	4.130	2.700	2.126	.116	.106	.200	.075	-	-	.119	.122	89.393	Knob sandst. and chert.
226	Russell,	2.221	3.44	4.170	4.478		-	.176	.066	.088	.227	-	.063	.068	90.786	Soil & sub soil from table land over limest. shales.
229	Wayne,	2.551	3.16	5.370	4.326	2.526	.236	.256	.246	.036	-	-	.115	.137	86.066	Lethostrotion cherty barren limestone.
234	Wayne,	8.534	8.28	2.560	10.240	3.120	.078	1.021	.922	.229	-	-	.351	.123	62.506	Meadow cr. bottom unproductive only for want of drainage.
581	Breckinridge,	1.827	2.625	3.532	2.080	2.215	.220	.022	.323	.108	.059	-	.194	.017	91.145	Intercalated sandstone over Archimedes limest.
582	Breckinridge,	1.900	2.600	5.030	1.640	1.490	.095	.147	.285	.139	.042	-	.198	.020	90.420	Archimedes and Productus bed.
641	Hardin,	2.078	3.760	5.069	1.936	2.860	.236	.270	.388	.396	.054	-	.208	.006	88.096	Slope of knob below encrinital cherty limestone, beech growth.
642	Hardin,	1.466	1.600	2.443	1.715	1.440	.095	.022	.209	.079	.016	-	.167	.032	93.020	Top Salt river hills.
643	Hardin,	2.742	1 965	3.417	2.245	2.075	.095	.197	.203	.177	.067	-	.104	.013	91.445	Soil from alternations of sandstone and barren & cavernous limestones.
644	Hardin,	1.992	1.500	2.309	1.745	1.420	.040	.097	.191	.078	.021	-	.075	.030	93.495	Soil from old field 39 years in cultivation.

645	Hardin,	2.093	1.965	2.407	2.670	2.415	.070	.147	.325	.096	.028	-	.092	.024	91.395	Sub-soil from old field 39 years in cultivation.
659	Jefferson,	1.822	3.100	4.231	3.580	4.421	.445	.230	.359	.260	.084	-	.167	.045	86.066	Soil from ash colored shale, mostly.
660	Jefferson,	5.194	3.175	4.983	3.245	4.130	.370	.195	.335	.295	.085	-	.213	.051	85.895	Sub soil from ash-colored shale, mostly.
670	Larue,	1.586	2.625	6.428	3.175	2.715	.230	.072	.290	.114	.059	-	.135	.025	88.680	Soil from lithostrotion (stylina) beds.
671	Larue,	1.970	2.425	5.380	3.175	2.815	.245	.106	.342	.113	.055	-	.123	.021	89.340	Soil from old field 30 to 40 years in cultivation.
672	Larue,	1.134	2.725	2.981	3.955	3.265	.235	.015	.467	.096	.050	-	.130	.023	88.625	Sub soil from old field 30 to 40 years in cultivation.
676	Meade,	1.627	2.840	3.911	1.896	2.040	.036	.136	.205	.151	.041	-	.259	.041	91.436	Soil from cavernous barren limestone.
677	Meade,	1.205	2.620	2.620	3.136	2.580	.116	.236	.298	.125	.130	-	.154	.084	91.036	Soil from old field 50 years in cultivation.
762	Taylor,	5.145	2.850	7.075	3.765	3.110	.095	.172	.435	.146	.103	-	.146	.046	85.245	Soil from ash colored & knob freestone, chiefly.
763	Taylor,	4.654	2.425	5.816	2.530	2.910	.120	.122	.423	.105	.067	-	.125	.052	87.330	Cherty limestone, chert cellular.

TABLE D.

Soils, Sub-soils, and Under-clays derived from rocks of Devonian date.

Number in report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soil. Remarks, &c.
583	Bullitt,	2.022	4.680	5.665	2.476	4.790	0.176	0.196	0.526	0.253	.054	-	.258	.058	85.056	Ash-colored black shales.
673	Marion,	3.409	3.375	4.786	6.495	3.565	.271	.222	.339	.262	.042	-	.157	.011	85.040	Soil from encrinital and hydraulic beds.
674	Marion,	4.478	3.400	4.748	3.940	4.970	.312	.222	.302	.280	.062	-	.181	.033	84.720	Soil from field 5 years in cultivation.
675	Marion,	1.360	3.200	3.679	4.645	5.360	.172	.297	.372	.279	.042	-	.212	.019	84.720	Sub-soil.

TABLE E.

Soils, Sub-soils, Under-clays, and Marls derived from rocks of Upper Silurian date.

Number in report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soil. Remarks, &c.
522	Jefferson,	-	4.42	7.996		7.418		0.394	0.240	0.205	0.082	-	0.200	0.043	83.134	Soil over cellular magnesian limestone.
523	Jefferson,	-	2.80	4.506		6.240		.316	.200	.191	.067		.158	.070	88.318	Soil from old field.
524	Jefferson,	-	2.98	2.844		6.335		.256	.226	.099	.082	-	.181	.028	89.900	Sub-soil from old field.
525	Jefferson,	-	3.60	3.112		17.020		.194	.366	.497	.088	-	.297	.111	77.434	Red under clay from old field.
526	Jefferson,	-	3.94	4.039		11.840		.236	.216	.126	.169	-	.239	.043	82.694	Soil from poor point in old field.
527	Jefferson,	-	2.700	-		33.900	4.28	.580	1.220	-	-	-	-	-	-	Gravel ore disseminated in sub-soil of old field.
528	Jefferson,	-	3.290	3.761		6.952		.156	0.240	.088	.340	-	.177	.031	88.294	Soil over compact magnesian limestones.
584	Bullitt,	1.390	2.920	3.120	2.390	2.740	.165	.182	.348	.097	.067	-	.145	.037	90.555	Soil from orthoceras and trilobite beds.
585	Bullitt,	0.834	2.725	3.696	1.890	2.215	.145	.072	.310	.070	.055	-	.104	058	91.695	Soil from old field 50 to 60 years in cultivation.
586	Bullitt,	1.321	3.250	3.229	4.345	4.495	.012	.197	.289	.109	.050	-	.235	.042	86.720	Sub soil from old field 50 to 60 years in cultivation.
719	Nelson,	4.816	3.750	5.298	3.890	3.875	.420	.270	.416	.114	.051	-	.098	.036	85.895	Soil from calymene magnesian limestone.
734	Oldham,	2.100	3.000	4.778	2.214	2.240	.172	.340	.328	.251	.067	-	.125	.027	89.420	Soil from favistella beds at junction Upper and Lower Silurian.
735	Oldham,	1.547	2.200	3.001	2.270	2.020	.145	.170	.275	.128	.076	-	.111	.039	91.295	Soil from field 20 years in cultivation.
736	Oldham,	1.237	2.575	2.643	3.355	2.540	.145	.125	.365	.112	.050	-	.130	trace.	89.820	Sub-soil from field 20 in cultivation.

TABLE E—Continued.

Number in report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture.	Organic & volatile matters.	Alumina,	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid.	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soil. Remarks, &c.
737	Oldham,	3.100	1.475	2.537	1.120	2.625	.072	.239	.233	.107	.079	-	.075	.056	92.747	Shale below magnesian limestone.
764	Trimble,	3.382	2.500	4.302	2.530	1.990	.170	.320	.232	.089	.033	-	.213	.047	90.195	Soil from magnesian earthy and cherty beds.
765	Trimble,	2.499	2.450	3.434	2.995	2.890	.170	.220	.291	.096	.020	-	.152	.049	89.920	Soil from old field 40 to 50 years in cultivation.
766	Trimble,	3.029	2.425	3.136	3.470	2.640	.245	.170	.294	.079	.015	-	.181	.028	90.160	Sub soil from old field 40 to 50 years in cul'vation.

TABLE F.

Soils, Sub-soils, and Under-clays derived from rocks of Lower Silurian date.

Number in report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture.	Organic and volatile matters	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soils. Remarks, &c.
557	Anderson,	2.201	4.125	5.463	1.615	6.305	0.315	0.345	0.335	0.181	0.056	not det	0.156	0.073	84.845	Soil from white oaklands on encrinital beds.
558	Anderson,	2.105	3.075	4.332	2.165	2.890	.220	.215	.465	.103	.032	-	.101	.047	89.140	Soil from old field 20 to 30 years in cultivation.
559	Anderson,	0.789	3.250	3.213	2.465	3.555	.220	.070	.601	.142	.056	-	.130	.026	88.970	Do. sub soil.
565	Boone,	4.600	4.635	7.827	2.495	2.790	.195	.395	.495	.318	.084	-	.175	.040	84.620	Leptæna, chætetes and earthy calcareous? beds. Beech woods.
566	Boone,	3.100	3.75	5.506	3.520	3.124	.245	.495	.469	.126	.187	-	.152	.032	85.595	Soil from old field 20 to 30 years in cultivation.
567	Boone,	1.936	3.19	3.455	3.945	3.420	.295	.265	.536	.476	.067	-	.213	.050	87.645	Do. sub-soil.
568	Bourbon,	6.078	5.12	8.406	5.745	5.185	.370	.945	.170	.335	.119	-	.227	.133	79.045	Soil from capax testudinaria shell earthy beds. Blue grass lands.
569	Bourbon,	3.149	3.84	5.574	4.925	4.185	.395	.485	.110	.330	.065	-	.209	.114	83.310	Soil from old field.
570	Bourbon,	2.263	3.84	4.196	5.360	4.313	.420	.355	.521	.440	.085	-	.195	.100	84.070	Do. sub soil.
571	Bourbon,	1.834	6.45	4.783	12.785	9.420	.495	6.235	1.946	.425	.050	-	.840	.116	63.770	Red shell earth under sub soil.
574	Bourbon,	6.760	5.865	7.702	4.620	6.585	.720	.622	.508	.321	.145	-	.224	.077	78.680	Favosites, lynx and occidentales beds of Cane ridge.
575	Bourbon,	2.834	4.500	5.837	5.195	5.910	.596	.446	.416	.282	.101	-	.248	.103	81.080	Do. from old field.
576	Bourbon,	2.671	4.600	4.785	5.275	5.660	.345	.421	.517	.243	.110	-	.217	.130	82.230	Sub-soil from old field.
577	Bourbon,	1.849	7.085	4.875	8.720	10.015	.470	.446	.753	.221	.093	-	.347	.159	74.145	Ferruginous under-clay.
27	Fayette,	-	4.44	8.00	4.181	6.17	-	.494	.420	.466	not det.		.205	.062	79.91	Soil from Leptæna and Chætetes beds.
28	Fayette,	-	4.58	5.98	4.528	7.190	.204	.530	.527	.379	-	-	.139	.031	80.43	Soil from old field.
500	Clarke,	2.093	4.16	6.100	3.940	4.920	.400	.470	.620	.480	-	-	.030	.080	82.65	Soil from orchard.

TABLE F—Continued.

Number in report.	County.	Dissolved from 1000 grains of water charged with carb. acid.	Moisture.	Organic and volatile matters	Alumina.	Oxide of iron.	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soils. Remarks, &c.
501	Clarke,	1.370	2.96	4.010	7.710	7.060	.290	0.990	1.040	0.380	–	–	.360	.030	78.030	Sub soil from orchard.
504	Fayette,	3.520	4.12	4.881		10.306		.276	.133	.254	.109	–	.139	.047	83.834	Soil from siliceous shales. Beech woods.
509	Fayette,	4.350	7.30	5.242		19.206		1.196	.426	.434	.054	–	.308	.086	72 994	Red sub soil over Leptæna and chætetes beds.
510	Fayette,	1.112	6.38	4.913		20.300		.116	.034	.383	.082	–	.309	.159	73.874	Red sub soil from another locality.
517	Franklin,	3.680	5.18	9.133		8.100		.316	.517	.243	.068	–	.173	.049	80.754	Soil from encrinital beds.
518	Franklin,	2.637	1.98	3.790		4.589		.196	.066	.151	.054	–	.135	.026	90.734	Soil from old field 12 years in cultivation.
518a	Franklin,	2.366	2.525	4.206	2.120	2.915	.004	.173	.233	.128	.043	–	.130	.051	90 170	Soil from old field 40 to 50 years in cultivation.
518b	Franklin,	.830	3.30	3.179	4.470	4.825	.005	.082	.312	.148	.033	–	.282	.002	86 380	Sub-soil from field 40 to 50 years in cultivation.
550	Woodford,	6.014	4.70	7.771		12.961		2.464	.173	.319	.150	–	.394	.130	75.266	Soil from Leptæna and bellerophon beds.
551	Woodford,	3.720	4.60	5.513		13.344		2.734	.333	.306	.037	–	.205	not de	77.594	Soil from old field 51 years in cultivation.
552	Woodford,	4.950	4.52	6.450		13.773		3.476	.354	.417	.082	–	.498	.095	75.434	Sub-soil from old field 51 years in cultivation.
553	Woodford,	1.000	5.04	6.065		33.377		.138	.080	.383	.198	–	.234	.127	59.360	Red under-clay.
580	Boyle,	5.683	3.500	5.958	3.515	3.835	0.320	.247	.571	.486	.119	–	.183	.071	83.770	Modesta beds. Mulatto soil.
590	Campbell,	2.874	3.350	5.614	3.084	2.685	.245	.274	.474	.245	.101	–	.158	.108	86.730	Lynx beds and siliceous mudstone.
591	Campbell,	1.386	1.925	3.441	2.290	2.110	trace.	.146	.592	.177	.119	–	.111	.052	91.095	Do. old field 50 years or more in cultivation.
592	Campbell,	.864	2.700	3.826	3.740	3.270	.055	.072	.430	.046	.076	–	.159	.048	68.845	Sub-soil from field 50 years in cultivation.

593	Carroll,	4.890	3.800	5.744	3.910	3.455	.222	.245	.527	.396	.054	-	.312	.022	85.483	Bottom land. Adjacent hill silicious mudstones alt. with limestones.
594	Carroll,	4.342	2.375	3.618	2.820	2.845	.195	.170	.340	.203	.038	-	.287	.064	89.921	Do. from old field 50 y'rs or more in cultivation.
595	Carroll,	1.919	2.300	2.814	2.470	2.630	.180	.280	.300	.227	.059	-	.256	.026	90.515	Sub soil from old field 50 y'rs or more in cult.
603	Franklin,	5.070	3.440	4.722	2.156	5.120	.038	1.490	.832	.304	.055	-	.212	.065	84.974	Soil not far from Cytherina limestone.
604	Franklin,	5.860	3.920	5.911	2.550	4.380	.376	1.470	.826	.433	.095	-	.251	.007	83.936	Soil not far from Cytherina limestone.
606	Franklin,	2.380	3.790	5.935	2.840	2.370	.290	.295	.296	.182	.084	-	.196	.040	87.280	Soil from encrinital beds near Cytherina limest'e.
607	Franklin,	1.525	4.125	3.911	3.220	4.290	.320	.305	.271	.350	.050	-	.200	.017	87.280	Soil from old field 40 y'rs in cultivation.
608	Franklin,	1.436	4.815	3.405	4.095	4.895	.335	.246	.450	.359	.081	-	.202	.029	85.810	Sub-soil from old field 40 years in cultivation.
611	Franklin,	1.000	4.400	4.205	6.390	7.240	.146	.097	.781	.182	.033	-	.444	.032	80.580	Under-clay.
612	Franklin,	3.083	5.625	7.072	3.890	4.785	.272	.495	.607	.404	.153	-	.215	.084	82.270	Soil from limestones No. 615.
613	Franklin,	3.037	4.250	6.292	3.975	4.045	.196	.430	.519	.305	.093	-	.206	.054	84.120	Soil from old field 40 to 50 years in cultivation.
614	Franklin,	.897	4.475	3.611	5.740	7.085	.222	.445	.383	.316	.101	-	.173	.048	82.450	Sub soil from field 40 to 50 years in cultivation.
619	Gallatin,	2.908	5 575	7.005	5.965	6.035	.320	.920	.768	.360	.114	-	.486	.013	77.770	Soil from silicious mudstone alternate with Leptæna and Orthis limest.
620	Gallatin,	3.441	6.000	6.543	5.715	6.170	.595	.970	.818	.310	.079	-	.354	.021	77.855	Sub-soil from do.
621	Garrard,	7.634	5.825	8.548	6.190	3.920	.520	1.910	.763	.559	.128	-	.393	.081	77.380	Soil over modesta and plicatella beds.
622	Garrard,	4 586	4.550	5.238	7.805	5.165	.649	3.270	1.358	.484	.059	-	.386	.025	75.570	Soil from old field.
623	Garrard,	3.186	4.950	4.234	8.577	5.745	.590	3.880	1.476	.513	.059	-	.354	.059	74.780	Sub soil from old field.
624	Garrard,	4.932	3.350	4.640	3.140	2.875	.270	.420	0.692	.379	.102	-	.121	.045	88.220	Soil from light grey limestone, near same geol. horizon, as No. 621.
625	Garrard,	3.343	3.365	4.987	3.040	3.844	.110	.385	.207	.335	.067	-	.106	.057	87.170	Soil from old field.
626	Garrard,	1.409	2.915	2.945	3.815	3 290	.210	.170	.412	.251	042	-	.120	.018	89.095	Sub-soil from old field.
627	Grant,	3.170	3.150	5.212	2.530	2 595	.222	.247	.472	.283	.093	-	.186	.083	87.845	Silicious mudstone.
628	Grant,	2.590	3.135	4.572	3.520	3.115	.222	.247	.433	.135	.080	-	.183	.071	87.595	Silicious mudstone from field 40–50 y'rs in cult.
629	Grant,	1.428	2.415	3.111	3.745	3.425	.212	.147	.379	.244	.045	-	.222	.052	88.650	Sub-soil from old field 40 to 50 years in cult.

TABLE F—Continued.

Number in report.	County.	Dissolved from 1000 grains by water charged with carb. acid.	Moisture.	Organic and volatile matters	Alumina.	Oxide of iron	Manganese.	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soils. Remarks, &c.
630	Grant,	2.743	3.225	6.162	2.815	2.734	.170	.196	.399	.203	.072	-	.133	.113	87.045	Silicious mudstone.
646	Harrison,	4.847	3.325	7.721	3.540	3.865	.420	.466	.483	.394	.114	-	.170	.077	82.895	Coarse semi crystal. bed.
647	Harrison,	4.077	2.750	6.051	3.655	3.835	.480	.296	.463	.385	.107	-	.159	.1[illegible]	84.630	Do. from old field 60 to 70 years in cultivation.
648	Harrison,	3.093	2.825	5.119	3.565	3.660	.345	.313	.491	.316	.101	-	151	.090	85.710	Sub soil from old field 60 to 70 y'rs in cultivation.
649	Henry,	4.617	4.075		2.515	3.940	.170	.372	.503	.615	.101	-	.284	.132	85.900	Soil from lynx bed, shaly & easily disintegating.
650	Henry,	2.439	3.935	5.159	3.915	4.115	.220	.496	.558	.407	.101	-	.298	.133	83.760	Soil from old field 50 years in cultivation.
651	Henry,	3·382	4.110	4.918	4.125	4.545	.160	.396	.512	.448	.085	-	.227	.067	84.943	Sub soil from old field 50 years in cultivation.
662	Jessamine,	4.210	2.900	4.737	2.695	2.890	.280	.345	.199	.133	.067	-	.121	.047	87.995	Soil from upper beds "Ky. river marble."
663	Jessamine,	3.212	2 950	4.250	3.695	3.240	.285	.295	.366	.239	.050	-	.185	.044	87.245	Soil from old field.
664	Jessamine,	3.985	4.200	5.349	5.065	4.990	.220	.595	.750	.666	.106	-	.344	-	81.720	Soil from testud. beds.
665	Jessamine,	8 083	6 775	9.745	9.190	5.840	.470	3.570	1.290	.532	.119	-	.569	.212	69.070	Soil from field in cult.
667	Kenton,	2 460	3.935	5.429	3.255	2.520	.199	.197	.461	.226	.076	-	.272	trace.	87.445	Soil from Leptæna shell beds and mudstone.
668	Kenton,	1.705	3.210	3.621	3 570	3.245	.345	.147	.460	.206	.074	-	.212	.035	87.495	Soil from old field 40 to 50 years in cultivation.
669	Kenton,	1.630	3.165	2.901	3.660	3.220	.320	.147	.470	.150	.050	-	.205	.060	88.745	Sub-soil from old field 40 to 50 y'rs in cultivation.
678	Mercer,	5.200	4.500	6.361	3.955	4.050	.345	.495	.341	.309	.076	-	.144	.024	83.712	Soil from Chætetes beds.
679	Mercer,	5.310	4.000	5 208	3.590	3.790	.295	.385	.365	.397	.098	-	.130	.036	86 250	Soil from field 20 years or more in cultivation.
680	Mercer,	4.00	3.700	4.389	3.750	3.415	.320	.395	.390	.362	.050	-	.114	.040	86.720	Sub-soil from field 20 y's or more in cultivation.
681	Mercer,	11.095	4.500	10.365	5 395	7.110	.620	1.995	1.234	.333	.093	-	.762	.106	72.035	Soil from Chætetes beds.
682	Mercer,	3.754	4.375	6 980	7.495	7.270	.645	2.080	1.184	.298	.090	-	.705	.106	72.810	Soil from old field 50 y's in cultivation.

683	Mercer,	6.157	5.000	7.252	8.315	7.335	.769	2.850	1.477	.459	.058	-	.650	.050	71.395	Sub-soil from old field 50 years in cultivation.
684	Mercer,	5.818	4.450	5.494	6.195	5.184	.490	14.170	.684	.456	.041	-	.817	.123	66.245	Under-clay from old field 50 years in cultivation.
714	Nelson,	5.855	4.985	6.659	4.655	4.065	.395	.770	.452	.535	.093	-	.222	.026	82.195	Soil from Chætetes and shell-beds.
715	Nelson,	2.389	2.700	3.423	3.140	2.825	.280	.330	.282	.316	.078	-	.130	.036	88.895	Soil from field 30 to 33 years in cultivation.
716	Nelson,	1.579	2.850	2.804	3.490	3.370	.220	.230	.254	.277	.059	-	.101	.034	88.970	Sub-soil.
717	Nelson,	1.620	5.575	4.090	8.240	7.065	.380	1.725	.731	.438	.059	-	.334	.052	77.275	Loose friable earth underlying same field.
718	Nelson,	1.746	5.050	4.449	7.290	6.015	.295	.520	.967	.368	.033	-	.283	.058	79.730	Silicious shell earth under sub-soil.
720	Nelson,	5.032	3.425	5.384	4.280	3.905	.470	.405	.492	.228	.117	-	.193	.049	84.395	Blue ash land over the earthy lynx beds.
721	Nelson,	3.842	3.250	4.858	4.070	3.795	.295	.222	.553	.351	.067	-	.268	.015	85.585	Do. from old field 40 y'rs in cultivation.
722	Nelson,	2.000	4.000	4.088	5.910	5.160	.320	.336	.487	.345	.065	-	.275	.055	83.210	Sub-soil.
723	Nelson,	1.956	5.275	6.281	9.325	7.885	.295	.645	1.100	.773	.062	-	.449	.272	73.095	Shell under earth containing silicified lynx.
724	Nelson,	5.892	2.575	7.195	3.295	3.110	.195	.445	.522	.342	.096	-	.154	.021	84.595	Blue ash land over shell earth.
725	Nelson,	4.895	2.640	7.164	3.495	3.535	.220	.520	.656	.343	.067	-	.125	.027	83.770	Blue ash land from field 14 years in cultivation.
729	*Nelson,	-	-	4.200	5.190	4.650	.230	.396	.613	.172	.085	-	.282	.095	84.495	Under shell earth of the blue ash land.
738	Owen,	1.850	3.225	3.978	3.970	3.290	.335	.180	.444	.179	.054	-	.256	.024	87.195	Soil from sil. mudstone.
739	Owen,	0.980	3.250	3.256	3.995	3.290	.180	.145	.388	.163	.050	-	.179	.017	88.170	Soil from old field 40 years in cultivation.
740	Owen,	1.501	3.050	3.146	4.343	3.575	.265	.195	.441	.163	.044	-	.262	.006	87.380	Sub-soil from old field 40 years in cultivation.
743	Pendleton,	3.354	2.450	4.766	2.290	2.685	.145	.296	.157	.227	.107	-	.207	.078	88.010	Soil from silicious mudstone.
744	Pendleton,	2.649	2.675	4.906	2.565	2.510	.145	.275	.341	.178	.055	-	.140	.037	88.570	Soil from old field 40 to 50 years in cultivation.
745	Pendleton,	2.183	2.450	3.459	3.500	3.200	.146	.162	.685	.195	.089	-	.188	.068	88.010	Sub-soil from old field 40 to 50 y'rs in cultivation.
748	Scott,	6 114	5.450	9.042	5.015	5.310	.565	1.020	.293	.438	.141	-	.214	.106	78.145	
749	Scott,	6.578	3.400	5.197	5.425	5.110	.502	1.195	.504	.319	.179	-	.197	.125	81.260	Sub-soil from old field 45 years or more in cult. Capax and mod. beds.
750	Scott,	3.599	3.415	4.669	6.740	5.735	.397	.595	.581	.323	136	-	.183	.031	81.880	Sub-soil from same field.

TABLE F—Continued.

Number in report.	County.	Dissolved from 1000 grains of water charged with carb. acid.	Moisture.	Organic and volatile matters	Alumina.	Oxide of iron and	Manganese:	Carbonate of lime.	Magnesia and carbonate.	Phosphoric acid	Sulphuric acid.	Chlorine.	Potash.	Soda.	Sand and silicates.	Member of the formation immediately under the soils. Remarks, &c.
751	Shelby,	-	3.700	3.193		13.130		1.290	.914	.284	.066	-	.395	.038	80.690	Marly earth associated with chætetes beds.
752	Shelby,	2.010	3.565	4.648	2.896	3.280	.170	.320	.406	.249	.064	-	.159	.026	87.222	Soil from chætetes beds.
753	Shelby,	1.851	3.400	4.503	3.070	3.190	trace.	.495	.366	.152	.050	-	.128	.051	88.050	Soil from field 25 years or more in cultivation.
754	Shelby,	1.117	3.350	3.336	3.174	4.080	.045	.235	.354	.196	.059	-	.214	.014	88.445	Sub-soil.
755	Shelby,	3.128	3.575	4.734	4.590	3.585	.270	.445	.533	.479	.128	-	.120	.097	85.670	Soil from chætetes beds.
756	Shelby,	4.279	3.225	4.970	4.115	3.660	.515	.546	.497	.259	.067	-	.173	.093	84.970	Soil from an old field.
757	Shelby,	1.614	2.925	3.245	4.690	3.865	.558	.246	.395	.393	.050	-	.208	.051	86.320	Sub-soil from old field.
758	Spencer,	2.798	3.350	4.317	3.096	2.590	.515	.345	.493	.187	.059	-	.236	.014	87.970	Soil from sub crystalline chætetes limestone.
759	Spencer,	2.111	2.425	2.973	2.496	2.640	.170	.245	.241	.144	.041	-	.183	.047	90.095	Sub soil from field 50 to 60 years in cultivation.
760	Spencer,	1.050	3.075	2.347	2.665	3.175	.164	.220	.454	.106	.062	-	.154	.030	90.320	Sub-soil from same field.
770	Washington,	6.750	5.050	7.753	3.790	3.930	.495	.636	.333	.488	.084	-	.231	.030	82.190	Soil from shell beds; Leptæna and Orthis.
771	Washington,	3.712	3.555	5.635	4.515	4.145	.420	.396	.233	.445	.067	-	.191	.011	83.940	Soil from old field 50 y'rs or more in cultivation.
772	Washington,	1.865	3.450	3.340	4.565	4.385	.345	.220	.308	.346	.042	-	.160	.038	85.175	Sub-soil from same field.
773	Washington,	3.982	3.300	4.576	3.440	2.990	.170	.322	.388	.196	.067	-	.154	.021	87.410	Soil from marls and shales of white oak lands
774	Washington,	2.306	2.150	3.055	3.015	3.390	.175	.222	.344	.161	.059	-	.132	.035	89.070	Soil from old field 50 years in cultivation.
775	Washington,	1.640	2.890	2.894	3.565	3.440	.170	.145	.443	.129	.077	-	.128	.052	89.020	Sub-soil from same field.

CHAPTER III.

CHEMICAL GEOLOGY.

MINERAL SPRINGS AND WELL WATER.*

The Saloon mineral spring, at Harrodsburg, in Mercer county, tested at the fountain head, gave as its principal constituents:

Sulphate of magnesia;
Bi-carbonate of magnesia;
Bi-carbonate of lime;
Bi-carbonate of iron, (small quantity;)
Trace of chloride of sodium;
Trace of chloride of magnesium?

The sulphate of magnesia is the characteristic salt in this water. Its effects will be that of a mild laxative and tonic.

The Greenville Spring, in the same vicinity, contains the same ingredients, only there are more chlorides and less iron, and a trace of free sulphuretted hydrogen; but the reaction for this ingredient is so feeble as to be hardly perceptible.

These springs issue from the beds of the blue limestone, near its junction with the underlying marble rocks.

The principal constituents of the Janes' mineral water, four miles from Springfield, in Washington county, are,

Free sulphuretted hydrogen, strongly impregnated;
Chloride of sodium, (common salt;)
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Sulphate of soda;
Sulphate of magnesia;

This spring rises through the lynx beds of the blue limestone.

The examination of the water of the public well, at Bloomfield, in Nelson county, showed the presence of

Chloride of sodium, (common salt;
Bi-carbonate of lime;
Bi-carbonate of magnesia;

*Continued from page 73, 2nd volume of Report of Geological Survey.

Sulphate of soda;

Sulphate of magnesia;

All of course only in small quantity.

R. B. Grigsby's "white sulphur" water, in Nelson county, tested at the fountain head, gave, as its principal constituents,

Free sulphuretted hydrogen, strongly impregnated;

Chloride of sodium, (common salt;)

Sulphate of soda;

Sulphate of magnesia;

Bi-carbonate of lime;

Bi-carbonate of magnesia;

Bi-carbonate of iron.

This water is milky from precipitated sulphur, thrown down by the action of the atmospheric oxygen as it comes to the air. It has a feeble alkaline reaction.

This water has valuable medicinal properties. It will act not only as a mild aperient, but on the skin and kidneys, while it possesses, at the same time, some tonic properties.

The principal constituents of the mammoth well, on the west branch of Simpson creek, in Nelson county, are,

Chloride of sodium, (common salt;)

Bi-carbonate of lime;

Bi-carbonate of magnesia;

Bi-carbonate of iron;

Sulphate of soda, (small;)

Sulphate of magnesia, (small.)

It is therefore, a weak saline chalybeate, possessing feeble aperient and tonic properties.

The "Washington Bell's mineral spring," now owned by Ex-Governor Wickliffe, issues from the Black Devonian slate on Sulphur Lick creek, in the extreme southern border of Nelson. By reagents, applied at the fountain head, the following ingredients, as its principal constituents, are determined:

Free sulphuretted hydrogen, strongly impregnated;

Chloride of sodium;

Sulphate of soda;

Sulphate of magnesia;

Bi-carbonate of lime;

Bi-carbonate of magnesia.

It has a distinct alkaline reaction. This water will no doubt be found highly beneficial in diseases of the skin, and in chronic complaints, especially when complicated with acid reactions of the system, besides being a mild aperient and diuretic.

The Hardinsville sulphur spring, which issues from the encrinital beds of the blue limestone, in the eastern part of Shelby county, contains, as its main constituents,

Free sulphuretted hydrogen;

Chloride of sodium, (common salt;)

Chloride of magnesium?

Bi-carbonate of magnesia;

Bi-carbonate of lime, (small quantity;)

Sulphate of soda, a trace;

Sulphate of magnesia, a trace.

This water has a slight alkaline reaction. It will be found serviceable chiefly in diseases of the skin, possessing, at the same time, diaphoretic and diuretic properties.

In the immediate vicinity of Eminence, in Henry county, a saline chalybeate water flows, apparently from the bone bed, elsewhere spoken of. On account of the source of this spring it would be interesting to have a minute quantitative analysis of it made in the laboratory, in order to ascertain whether it contains a notable quantity of phosphates or other ingredients derived from the bone bed, over which it flows. It has a very peculiar taste, which seems to indicate some peculiar organic principles in it.

The mineral water at the Drennon Springs, is a strong sulphuretted saline, containing, as its most abundant ingredients,

Free sulphuretted hydrogen;

Chloride of sodium, (common salt;)

Sulphate of soda;

Sulphate of magnesia;

Bi-carbonate of lime;

Bi-carbonate of magnesia.

This is a very fine mineral water, acting not only on the skin but as a mild aperient, diuretic and diaphoretic.

In the bed of the head waters of Cedar creek, at Harmony, in Owen county, there is a weak saline water, containing,

Chloride of sodium, (common salt;)
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Sulphate of soda, (a trace;)
Sulphate of magnesia, (a trace.)

This water may be stronger in a low stage of water, since, at the time it was tested, the water of the creek had access to the spring. It has a slight alkaline reaction.

The principal ingredients found in the pool of water, at the foot of an oak tree in Barton Mathers' pasture, which runs over the out-crop of the silicious mudstone, in the adjacent hill side, were,

Chloride of magnesium;
Chloride of sodium?
Bi-carbonate of magnesia;
Bi-carbonate of lime;
Sulphate of soda;
Sulphate of magnesia;
Suspended alumina, (or else fine silicious earth?)

There are no poisonous metals in this water, since sulphuretted hydrogen, passed to saturation through it, only slightly increased the milkyness; no doubt from precipitation of alumina, or possibly, from a little sulphur produced from the reduction of the sulphuretted hydrogen, caused by the presence of a trace of peroxide of iron. This water is remarkable for the large quantity of magnesia present, which is much above the normal quantity even in waters flowing from the blue limestone, which probably exists, in part at least, in the state of chloride. I have little doubt but this water acts first as an astringent, and finally as an irritant and debilitator of the system.

Many cattle have died suddenly in the enclosure where this water collects, not long after drinking at the above pool, in dry seasons of the year, with symptoms of weariness, giddiness, or an affection in the head, which causes cattle to keep the head in constant motion from side to side; and a bloody appearance is seen on the surface of the mucous membrane of the intestinal canal after death.

The lower Blue Lick water was tested, quantitatively, by Dr. Peter,

under favorable conditions for exhibiting its valuable properties as a medical water, which will appear in his report.

I was not able to apply chemical tests to the Esculapian Springs under favorable circumstances, as a blast had recently been put into the black slate from which it issues, which had not only rent the strata so that a large portion of the water had been diverted from its original channel, but had given access to fresh water, by which it was much weakened. The ingredients found were:

Free sulphuretted hydrogen;
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Chloride of sodium, (common salt;)
Chloride of magnesium?
Sulphate of soda;
Sulphate of magnesia.

It is a sulphuretted saline water.

The "Alum Spring" is a weak saline chalybeate, with perhaps a trace of sulphate of alumina and iron. In a dry season this spring is doubtless stronger than when I tested it.

The principal constituents of the saline water of the Olympian Spring, in Bath county, were found to be,

Chloride of sodium, (common salt;)
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Bi-carbonate of iron, (a trace;)
Sulphate of soda;
Sulphate of magnesia;
Hardly a trace of free sulphuretted hydrogen at the time of testing.

The so-called "Black Sulphur Spring" yielded a similar result, only it gave a rather more distinct indication of free sulphuretted hydrogen.

The "Salt Spring" differs only in having a rather large proportion of common salt.

One mile from the Olympian Spring there is a saline water, in a well sunk in the flats, strongly impregnated with sulphate of magnesia, from which Epsom Salts could, no doubt, be made with as much facility as from the Crab Orchard waters.

A quarter of a mile north of the Olympian Spring a fine chalybeate water issues from under a rugged bench of yellow magnesian lime-

stone, depositing large quantities of hydrated oxide of iron in its course.

The Sudduth Springs, on Mud Lick, were also tested, and found to contain,

Bi-carbonate of lime;

Bi-carbonate of magnesia;

Bi-carbonate of iron;

Chloride of sodium;

Chloride of magnesium; and probably a trace of sulphuret of alkali.

The most iron was found in the spring under the small house or shed.

These springs were, however, in a bad condition for making a satisfactory examination, as they wanted cleaning out.

The chemical examination at the fountain head, of the Sweet Lick Estill Springs, gave, as the principal constituents,

Free sulphuretted hydrogen;

Chloride of sodium, (common salt;

Bi-carbonate of lime;

Bi-carbonate of magnesia;

Sulphate of soda;

Sulphate of magnesia?

It has a slight alkaline effect.

The Irvine Sulphur Spring contains the same ingredients, but in smaller quantities. They are both saline sulphuretted waters, having an action on the skin and kidneys, and may act as a mild aperient on some constitutions.

The "Russell Sulphur Spring," on the high table land of Russell county, contains, as its principal ingredients,

A small quantity of free sulphuretted hydrogen;

Sulphate of soda;

Sulphate of magnesia;

Chloride of sodium;

Chloride of magnesium;

Bi-carbonate of lime;

Bi-carbonate of magnesia.

The "Russell Chalybeate Spring" contains,

Bi-carbonate of lime;

Bi-carbonate of magnesia;

Bi-carbonate of iron;

Trace of sulphate of sodium;

Trace of sulphate of magnesia.

There is a strong sulphuretted saline mineral water, that rises in the bed of Kettle creek, in the extreme southwestern corner of Cumberland county, which contains

Free sulphuretted hydrogen, (strong;)

Sulphate of soda;

Sulphate of magnesia;

Chloride of sodium, (common salt;)

Bi-carbonate of lime;

Bi-carbonate of magnesia.

It has a slightly alkaline reaction, and is no doubt a valuable mineral water if excluded from the fresh water of the creek.

The principal constituents of Mrs. Creel's sulphur spring, in Marion county, are

Free sulphuretted hydrogen;

Sulphate of soda;

Sulphate of magnesia;

Chloride of sodium, (common salt;)

Chloride of magnesium?

Bi-carbonate of lime;

Bi-carbonate of magnesia.

It has an alkaline reaction on redden litmus and georgina paper. It is a sulphuretted saline water of moderate strength.

The principal ingredients of the Campbellsville Sulphur Water, in Taylor county, are

Free sulphuretted hydrogen;

Chloride of sodium;

Sulphate of soda;

Sulphate of magnesia;

Bi-carbonate of lime;

Bi-carbonate of magnesia.

In former times, some salt has been made from this water, and it rises from the locality of a noted lick. It has a slight alkaline reaction on reddened litmus and georgina papers.

Linsey's mineral water in Christian county, gave as its principal constituents,

Free sulphuretted hydrogen;
Chloride of sodium, (common salt;)
Chloride of magnesium?
Sulphate of soda;
Sulphate of magnesia.

Its temperature was 71° Fahrenheit, the temperature of the air being 81°.

This water has a bluish scum on the surface, a very sweet taste, and is, in fact, so strongly impregnated with sulphuretted hydrogen that few persons can drink it at first. The water issues through the fissures of the sub-carboniferous limestone, on the banks of Little river. It has a slightly alkaline reaction, which, however, is only perceptible after the test paper has been sometime immersed. This mineral water will act energetically on the skin, kidneys, and moderately also on the bowels, and must be a water of great efficacy in certain forms of disease, especially those of the skin.

CHAPTER IV.

STRATIGRAPHICAL GEOLOGY.*

FRANKLIN COUNTY CONTINUED.

The portion of Franklin county adjoining Scott and Woodford counties, which I have visited this season, is, for the most part, level and well situated for cultivation, except those farms immediately adjacent to Elkhorn.

In the vicinity of Mr. Wingate's where another Franklin county soil was collected for chemical analysis, it is emphatically ash, locust, walnut and burr-oak land. The original forests of these trees had a dense undergrowth of spice-wood and cane. The black locust attains here a great size—three feet through—and the honey locusts were very numerous in the primitive woods, but thousands of them were destroyed in the opossum and raccoon hunts of the early settlers, in which trees these animals usually take refuge from their pursuers. Both the blue and black ash flourish here; also sugar tree, spanish, and chincapin oak, buck-eye, coffee-nut, and hackberry.

This, and the part of Franklin county adjacent to the Versailles turnpike, embraces some of the finest blue-grass regions of the county. Wheat succeeds best where the lands are underlaid by the tenacious subsoil. According to the statements of some of the most experienced farmers these soils of Franklin county produce now better crops of wheat than did the original virgin soil. Locally the underclays are charged with gravel or "shot" iron ore; for the depth of two to three feet below which is found, in the part of the county adjoining Woodford, an unctuous or soapy clay.

A set of soils were collected by Robert W. Scott, from his farm, for chemical analysis; the result will be seen by consulting the Chemical Report, Nos. 612, 613, and 614. No. 615 is the analysis of the underlying rock, which is a mottled shell and Chætetes limestone.

There is a variety of oak land, in the part of Franklin adjacent to Scott, around Mr. Gregory's farm, which is considered excellent wheat land. I have not yet had an opportunity of collecting a soil from that part of the county. The nearest underlying rocks are thin bed-

*Continued from page 114, of the second volume.

ded, earthy, shell. and coralline limestones, with but few marly partings, belonging to the middle beds of the blue limestone formation, characterized especially by *Leptæna* and *Chætetes*. A peculiar bed of the same formation, that lies about ten or fifteen feet beneath the level of the turnpike leading into Scott county, is esteemed the best building stone that can be obtained from the blue limestone formation of the eastern part of the county. The thickest and best building stones are quarried on John R. Scott's land, and the farms adjacent to South Elkhorn. They can be obtained in dimension stones of from one to five feet. This rock has been used in foundations of some of the best houses in the county, as well as for gate-posts and steps, and has stood well the test of years of exposure in trying situations. It splits well, and when freshly quarried it is easily worked with the chisel, and takes even a partial polish; but it is rather too porous to make a good marble. This rock not only stands the action of frost, but even strong radiating heat, without cracking, placed in the side and jambs of fire-places. It becomes a valuable material in a region of the more earthy fossiliferous beds of the blue limestone formation, which are so prone to disintegration that it is not safe to use them in structures which require great durability. The same kind of building stone occurs at the Big Spring, in Woodford county, but of a more porous texture, and less uniform from the occurrence, at this locality, of disseminated fossil shells.

The chemical analysis of the soil No. 603 and 604, and the rock No. 605, from the so-called "Sick Spots," show most satisfactorily that there is nothing in them to which the sterility of these circumscribed areas can be attributed. The cause must, undoubtedly, be sought for, as already hinted at elsewhere, in the exhalation of carbonic acid issuing through rents, fissures, or cavernous spaces in the underlying limestone.

The result of the analysis of the soils from the Julian farms will be seen by consulting Dr. Peter's Report, Nos. 606, 607, 608, 611, 612, 613, and 614.

Near high water mark of Elkhorn the same Chætetes beds of the blue limestone formation crop out which are shown in the Kentucky river section, at Frankfort, above the Arsenal, about one hundred and forty feet above low water; these are overlaid by similar concretion-

ary layers, such as occupy the higher grounds between the Arsenal and the Cemetery lot.

Some of the best lead ore, which has come, as yet, under my observation, derived from veins in the blue limestone formation of central Kentucky, has been taken from a fissure traversing this rock formation, on the banks of North Elkhorn, near Dr. Duvall's farm. About a thousand dollars were expended here by Mr. Bradley, in attempting to work this vein, and a considerable quantity of ore was obtained, but not sufficient to repay the expense of working it.

In boring for water, near the paper mill on Main Elkhorn, six miles from Frankfort, a reservoir of inflammable gas was struck in the blue limestone formation, and the water obtained is said to have been strongly impregnated with magnesia.

SCOTT COUNTY, CONTINUED.

The rocks on North Elkhorn, in the western part of this county, are the *Orthis testudinaria* and *Chætetes lycoperdon* beds of the blue limestone, such as occur in the Frankfort section from one hundred to one hundred and forty feet above the Kentucky river—the former being about five feet above the bed of North Elkhorn, below the dam, of unusually large size.

East of Georgetown grey and blue Leptæna layers of the blue limestone prevail; one, which is semi-crystalline, is almost entirely composed of such shells. The beds are generally from two to six or eight inches thick. The higher beds contain *A. capax* and small varieties of *Chætetes lycoperdon*. The prevalent *Leptæna* appears to be *L. filitexta*.

The geological and consequent agricultural character of the southern part of Scott county partake of that of the adjacent portions of Woodford, Franklin, and Bourbon counties; while the northern part is more broken, and the soil is derived more, or in part, from the silicious mudstones. Both varieties of soil have been collected for chemical analysis.

ANDERSON COUNTY.

This county is located entirely within the range of the blue limestone formation of Lower Silurian date. In the eastern part of the county, along the course of Bond creek, the upper beds of the Ken-

tucky river marble series extend to near high water mark, surmounted by the beds of the blue limestone. The principal ledges of the latter formation, exposed to view, are the *Capax*, *Lycoverdon*, and encrinital beds.

A soil was collected for chemical analysis, from the ridge of white oak land that runs nearly north and south, near the sources of Big and Little Benson and Hammond's creek, elevated about three hundred feet above the Kentucky river, from John M. Walker's farm. Mixed with the white oak this land supports a growth of sugar-tree and hickory, with some gum-tree. The distance to the rock is usually six to eight feet. The under-clays and substrata are usually so retentive of water that cisterns can be made without cement, by only digging a hole in the ground.

The nearest underlying rock of the white oak land is a rough surfaced limestone, in which but few fossils can be recognized, excepting some small entrochites. By consulting Dr. Peter's report, under the head of Anderson county—Nos. 557, 558, and 559—the composition of this soil may be seen to fall short of those derived from the more fossiliferous and earthy beds of the blue limestone formation in Bourbon, Fayette, and Woodford counties.

BOURBON COUNTY.

This county contains as fine a body of genuine blue grass lands as can be found in the state, lying, for the most part, level or gently undulating, except the Flat Rock region, adjoining Bath, which is more broken. It is all based on the blue limestone formation. In the western part of the county the prevalent beds are thin bedded blue and grey *Leptæna* and *Chætetes* layers, underlaid by the *testudinaria* beds, and overlaid by strata containing a small variety of *A. capax* and *Leptæna filitexta?*

Two varieties of soil have been this season collected for chemical analyses, from this county. One from the northwest part of the county, from Wm. P. Hume's farm, on the divide between Huston creek and Cooper's run. This land supports a growth of blue and black ash, honey-locust, walnut, sugar-tree, wild-cherry, buckeye, and box-elder; undergrowth, hawthorn, young elm, mulberry, hackberry, besides young trees of many of the species previously cited.

The superiority of this soil is clearly shown by the analysis in Dr. Peter's report, No. 568. It exceeds even the fine Woodford soil in the amount of phosphoric acid. The sub-soil, shell-earth, and under-clay, Nos. 570 and 571, contain a most extraordinary per centage of that substance; and the shell under-earth, No. 571, is, besides, richer in potash than any soil, sub-soil, or under-clay that has yet been analysed. This shell earth is full of fragments, and even tolerably perfect specimens of *A. capax* and *O. testudinaria;* and the nearest underlying rock is charged with the same fossil shells, weathering rough, with some cherty seggregations, under which is a smoother and thinner bedded bluish grey limestone, with rusty surfaces, of which about five feet are exposed in the quarries where rocks are obtained for the stone fences.

The soil derived from these upper shell beds is a remarkably fine, loose, mellow, calcareous loam, peculiarly adapted for blue-grass. It is not quite so light a soil as the best hemp soils of Woodford, but yields crops of hemp but little inferior to those of that county. It is found so well adapted for grasses that the farms here are almost exclusively grazing farms, raising only what little grain is necessary to feed the stock, occasionally, in winter.

The other variety of Bourbon soil, collected for analysis, is from the "Cane Ridge;" the sample being taken from William Buckner's farm, amongst the huge burr-oak timber which forms a marked feature in the growth of timber of this part of the county, associated with sugar-tree, honey-locust, buckeye, and box-elder. The under-clay has much decomposing gravel iron ore disseminated; the underlying rocks belong to the upper series of the blue limestone formation of Kentucky, characterized by *Favosites maxima, O. lynx, O. occidentalis, Leptæna alternata,* and branching *Chætetes;* the latter are abundant in the beds immediately underlying the Buckner farm, along with *O. occidentalis.* The soil is very deep, with here and there large blocks of reddish-grey limestone, lying half buried in the soil, and nearly concealed by the luxuriant sod and tall growth of blue-grass, singularly congenial to this soil. Nos. 574, 575, 576, and 577, of Dr. Peter's report, exhibit the composition of this variety of Bourbon soil. By consulting these it will be seen that the soil is nearly equal in the amount of phosphoric acid to the variety just cited, but the sub-soil and under-clay, though still rich in that acid, fall short of the amount found in

the sub-soils and under-shell-earth of the Cooper's creek lands, and the amount is less, instead of greater, than in the surface soil.

Four varieties of limestone, underlying the Cooper's creek and the Cane Ridge lands, have received a chemical examination, and the result will be found in Dr. Peter's report, under the head of Bourbon county, Nos. 572, 573, 578, and 579. The first two contain the largest amount of the mineral food of plants, the *A. capax* bed, No. 572, being, on the whole, the most valuable for agriculture; though No. 573 contains the largest amount of sulphuric acid. They all, however, bespeak the fertility of the derivative soil.

In the early settlement of the country an abundant, general, large undergrowth of cane gave name to the Cane Ridge of land, which is about a mile wide, lying between the waters of Stoner and Hinkston.

The farms of Bourbon county are chiefly laid down in blue-grass, affording pasture for large herds of the celebrated stock—the staple commodity of the county.

On the divide between the waters of the Licking and Kentucky river there is a narrow strip of sobby beech land, like that extending through the adjacent part of Fayette, and ranging nearly north and south.

Near the toll-gate, on the Flat Rock turnpike, the *A. capax* beds appear in perfection, and in the surface rock in the high grounds, some seventy to eighty feet above the market-house in Paris, and one hundred and fifty to one hundred and sixty feet above the forks of Huston and the Stoner branch of the Licking river.

Some distance below the *capax* beds are some earthy marlites resembling the graptolite beds, in the hills about Cincinnati, near the water works; but none of these fossils were discovered, as yet, in this rock, only a cast of a bi-valve—(*modiola?*) The rocks are here dipping to the east from a half to one degree.

WOODFORD COUNTY

Is as celebrated for its hemp land as Bourbon and Fayette are for their grass lands. Its farms lie remarkably well for cultivation, having generally only slightly undulating surface.

Of the chemical composition of the variety of soil that prevails about the centre of the county, near Judge R. C. Graves', and the un-

derlying rock, we have already discoursed on at length in the second chapter of this report.

For 330 feet the rocks are exposed at intervals, and in benches and interrupted outcrops in the west part of the county, bordering on the Kentucky river, near the mouth of Grier's creek, as follows:

Feet.
320. Top of the ridge.
300. Orthis subjugata? beds.
275. Atrypa capax beds.
250. Layers containing small *Chætetes lycoperdon and Leptæna deltoidea?*
200. Layers containing branching *Chætetes.*
185. Main *Chætetes lycoperdon* beds.
160. *Orthis testudinaria* beds.
155. *Orthis* beds.
130. *Leptæna sericea* beds.
120. Top of beds "Kentucky river marble," possessing a kind of Birdseye structure.
110. Similar rock.
105. Do. white compact and regularly bedded.
85. Top of schistose layers.
Do. in descending stratification.
72. Top of bench of white birds-eye structured limestone.
5. Base of cliffs of banded, compact beds of birds-eye structured limestone,
0. Kentucky river, near the mouth Grier's creek.

These strata are traversed on Grier's creek, not far from the Kentucky river, by apparently two sets of veins, containing sulphate of barytes, a white cherty rock with disseminated sulphuret of lead and zinc—one running nearly north and south, the other quatering northeast and southwest; this is probably the same vein spoken of, under the head of Franklin county, worked for lead by Bradley, on North Elkhorn, and of which we have given the result. It seems to run from Moseby's cliff to Big Sinking creek, and is said by J. P. Bundy, the blacksmith in this vicinity, to show itself near the level of the Kentucky river, at Hunter's ferry, in Jessamine county, and is perhaps connected with the fault noticed near the Kentucky river, in Garrard county. This vein is four to six inches where it was seen on Grier's creek, cutting through a layer of *Atrypa modesta* limestone, in the bed of that creek.

Wells sunk some one hundred feet in these limestones afford water often impregnated with mineral matters. That sunk by Reuben Jesse was found, by re-agents, to contain,

Free sulphuretted hydrogen;
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Chloride of sodium, (common salt;)
Chloride of magnesium?

Singular detached masses of porous fossiliferous limestone are characteristic of the surface formation near Versailles. This is the same rock which was analyzed by Dr. Peter, and recorded in the second volume—No. 549—containing *Bellerophorons and Pleurotomarias*. This rock seems to have resisted decomposition longer than the subjacent matrix, and often stands out in bold relief above the surface. Near the masses the soil is usually rich and productive, but the land is rather disposed to be wet and sobby. The soil, and especially the sub-soil, is often of deep brown, red, or mulatto color, seldom light-colored. The redness is due to a quantity of iron in the subjacent rock formation, which is so abundant three miles east of Versailles, and half a mile from the turnpike, that it has given origin to quanties of gravelly bog ore frequently struck in digging cellars, even at considerable depths beneath the surface.

The principal growth of timber, in the central part of this county, is sugar-tree, pignut hickory, hackberry, ash, walnut, mulberry, and, north of Versailles, remarkably large poplar. Under-growth, pawpaw and elder.

FAYETTE COUNTY.

After ascending from Elkhorn to the upland, in the eastern part of Fayette county, the soil and rocks have much the same character as in Woodford county east of Versailles. Some of the beds of the blue limestone seem to be impregnated here with bitumen, as they emit a strong fœtid bituminous odor when struck by the hammer; the waters, too, from deep wells, of fifty to one hundred feet, have a petroleum taste. The water from the deep well sunk in Lexington, by Mr. Wilson, is highly charged with carbonic acid, and is a remarkably strong chalybeate.

The growth in Fayette was originally pignut hickory, large overcup oak, white-oak, ash, black and honey locust, buckeye, and mulberry, much the same, indeed, as in Woodford, and in both counties, in the early settlement of the country, there was a luxuriant growth of

cane and pea vines, which appears also to have been the case over large tracts of the richer portions of the blue limestone formation of Kentucky, even on high ridge land.

The layers of limestone, near the surface, are usually thin and of a rusty grey color; but when followed back into the quarries the color is usually of a bluish-grey, because, where the rock has been protected from the action of the air, most of the iron present is in the state of protoxide, which rusts by exposure. In sinking the well at the Lunatic Asylum, ten feet of a reddish under-clay was passed through; then two to three feet of a dark muddy-looking earth; then one to two feet of ash-colored marly clay, resting on the first rock, which was seventeen feet below the surface; eighty-nine feet of the various strata of blue limestone was then passed through, when the auger dropped eighteen inches and the water rose fifty feet in the bore. The water contains a little sulphuretted hydrogen and a small portion of salt—about ten grains to the gallon—enough to act slightly on the skin and kidneys, but has little or no effect on the bowels.

In the Van Akin quarry, near Elkhorn, where there are about twenty feet of rock exposed, the upper layers of limestone are thin and shelly; the lower beds are six inches to one foot. The passage in color, from more or less exposure to the air, is well seen here, the beds gradually changing from the dark-grey-blue below, through the various shades of grey-brown and red, above.

The best dimension stones have been obtained from a quarry recently opened between the Danville railroad and the cemetery lot, for the construction of the inner walls of the foundation of the Clay monument. They can here be quarried from one foot to one foot eight inches in thickness.

In the lower beds of the Van Akin quarry some good specimens of *Isotelus* (*Asaphus*) *gigas* have been found; the layers above contain *Chætetes lycoperdon*, and imperfect specimens of *Leptæna* and *Atrypa* and *Receptaculites*.

Some of the cavernous spaces in the limestones, near Lexington, are supposed to have a subterranean intercommunication with some of the Georgetown springs, since, it is believed by some, that substances thrown in at Lexington have made their appearance in the springs at Georgetown; however, the prevalent direction of the sink-holes, which

mark the place of cavernous spaces beneath, is more frequently east and west.

The quarries at the east end of the city present much the same character, except that the layers are thinner and perhaps more fossiliferous —*Atrypa* and *Orthis* and *Leptæna* predominating. Seams of calcareous spar traverse some of the beds. Cherty fragments, often porous or cellular, are disseminated in the red clay which overlies the rock layers, in which some good specimens of *Certolites?* are occasionally found.

In the cut of the Lexington and Big Sandy railroad between the Richmond and Winchester turnpikes, layers of the fine-textured silicious mudstone and shale, Nos. 505 and 506, of Dr. Peter's report, have been exposed, interstratified with a brownish-ash-colored clay. These are undoubtedly the beds which give origin to the narrow ridge of "sobby beech flats" from which soil No. 504, of Dr. Peter's report, was collected; this is the poorest strip of country in the whole of Fayette county.

The red clays, over the blue limestone, in the eastern part of the county, have often considerable quantities of gravel iron ore disseminated.

Four miles west of Clay's ferry the grey Chætetes beds of the blue limestone are exposed, in beds of from nine to eighteen, and even twenty-four inches thick.

The section on Boone's creek, where the buff magnesian limestone, known as Grimes' building stone, are obtained, presented the following section:

Feet.	
315.	Layers containing branching forms of Chætetes, *A. Modesta, Murchisonia.*
302.	Layers with branching Chætetes.
276.	Concretionary layers of blue limestone.
260.	Thin beds containing large Chætetes lycoperdon.
235.	Layers containing *Orthis (subjugata?) A. Capax, and Chætetes.*
210.	Dark bluish grey beds, with rough surface.
205.	Thicker coralline beds.
190.	Shell beds, mostly broken specimens of *O. testudinaria.*
170.	Bluish-grey sub-crystalline limestone.
160.	First appearance of birds-eye structure.
155.	Chert bands.
150.	Chert over
	Birds-eye structured limestone.

111. Do. in beds from one foot to eighteen inches.
105. Do., close textured.
100. Do. in beds from three to six inches.
Do., softer.
75. Birds-eye structured limestone, in beds of six inches.
Do. in beds from three to six inches.
62. Do., more schistose in structure.
60. Do., presenting darker shades of color.
58. Birds-eye structured limestone of close texture.
55. Bluish-grey bed.
52. Top of the buff magnesian building-stones of Grimes' quarry, of fine texture, affording dimension stones of from one foot to five feet.*
20. Buff members, thinner bedded.
0. Boon's creek.

Three varieties of this magnesian building stone have been analyzed by Dr. Peter—Nos. 511, 512, and 513; by consulting page 69, of the second volume, and the above numbers under the head of Fayette county, in Dr. Peter's report, the result will be seen.

Near Rogers' mill, one and a half miles from Grimes' quarry, to the north of the Clay's ferry road, hard beds of buff magnesian limestone are found, thirty-five feet under the chert beds, of which can be seen ten feet in natural exposure, and an other bed of similar rock, ten to fifteen feet under the chert bed, five feet in out crop, both apparently at a higher geological level than Grimes' building stone, and situated from one hundred and forty-seven to one hundred and seventy feet above Boone's creek. The rock may be somewhat harder to dress than Grimes' building stone, but could be quarried with less stripping, as it lies near the surface slope of the country.

The top of the Kentucky river marble rock is nearly one hundred feet higher, above the Kentucky river, at Clay's ferry, than at Frankfort, without making allowance for the fall of the river between those two places, which has not been determined.

The lowest stratum visible, near low water of the Kentucky river, at Clay's ferry, is a light-greyish-blue variety of the Kentucky river marble, mottled with pale buff, in which are imbedded peculiar shaped multilocular shells, probably of an undescribed genus; it tapers rapidly; is annulated at its lower part so as to resemble an encrinite

*The thickest dimension stones which I measured in the cemetery lot at Lexington, from the Grimes' quarry, was two feet two inches; but there appears to be some of the beds in this section that could be got out four to five feet.

stem, the whole fossil being slightly curved. The surface of this limestone, in place, is weathered into small cavities and channels, both curved and vermicular, once occupied by branching corals or plants now decayed and gone, which often form a complete net work on the surface of the slabs, though too much worn and defaced to make out their true character. The strata dip here slightly to the north. The following are the different layers observed between one hundred and five and two hundred and eighty-five feet above the river, in the cut of the turnpike:

285. Cherty fragments.
Rocks concealed.
270. Close textured Kentucky river marble, grey and brittle.
265. Close textured Kentucky river marble, grey and brittle.
262. Close textured Kentucky river marble, beds of two feet.
262. Quarry rock, banded in broad stripes of buff and grey, thin bedded.
245. Quarry rock, in beds from nine inches to two feet.
240. Buff bed, two feet.
230. Grey quarry rock, close textured, and rather brittle. (Here a *Pleurotomaria* is found, allied to, but probably distant from, *P. umbilicata*.)
220. Grey quarry rock, in beds from six to fourteen inches.
118. Base of quarry rock—two beds—mottled grey and buff.
216. Pale buff building stone, somewhat schistose in structure, and rather disposed to disintegrate.
215. Fine textured pale buff magnesian limestone—the best stone for building purposes—in beds of six, ten, and eighteen inches.
210. Base of same.
205. Buff beds, rather schistose.
200. Beds, mottled buff and grey.
195. Grey building stone, in beds of six to twelve inches.
187. Grey building stone, in beds of six to twelve inches.
180. Light buff building stone in beds of eighteen inches.
175. Grey beds of building stone of regular fracture.
170. Grey beds of building stone in beds of twelve to eighteen inches, with marly layers below.
165. Buff magnesian building stone.
162. Greyish buff quarry stone, in beds of eighteen inches.
160. Regular Kentucky river marble.
155. Concretionary layers.
150. Mottled layers, schistose and disposed to disintegrate.
145. Same, full of cavities and channels.
135. Same, with some geodes.
125. Same, with numerous markings of corals or plants?
120. Same, with imperfect univalves.

115. Beds mottled like the lowest beds.
105. Buff beds.

Nearly the whole of this section represents different varieties of the Kentucky river marble, with intercalated beds of magnesian building stones, a continuation of which extends, in fact, down to the level of the Kentucky river, at Clay's ferry—the lowest beds of which have been previously noticed—and all lying beneath the *Orthis testudinaria* beds of the blue limestone formation.

The summit of the country near the intersection of the Richmond turnpike and the road to Nicholasville is about four hundred and eighty feet above low water of the Kentucky river, at Clay's ferry, and about two hundred feet above the top of the Kentucky river marble, seen in this section.

CLARKE COUNTY.

The greater part of this county is based on the blue limestone. There is only a small portion of the southeast corner where the superior rocks are seen. Near the mouth of Howard's lower creek, the Kentucky river marble rock is brought, by an abrupt fault, to the surface, and forms, on the north side of the Kentucky, a vertical cliff of upwards of ninety feet. On the south side of the fault ledges of the ordinary blue limestone extend down to the river; on the north side of the dislocation the following members were observed, at various elevations above the Kentucky river:

390. O. occidentalis beds, near the top of the hill.
340. Chætetes beds of blue limestone.
310. Irregular bedded layers of blue limestone.
260. Blue limestone observed in place. Place? of *O. testudinaria* beds, seen afterwards on Howard's creek, near this level, but not seen on the immediate line of the section.
220. Top of ledges of Kentucky river marble observed in place.
195. Same, presenting a rugged surface.
188. Ledges of nearly white "birdseye" structure. Close textured limestone.
173. Schistose, thin bedded layers of same.
170. Thick bedded layers of same.
160. Top of bench of same.
150. Similar rock.
145. Bottom of nearly white ledge of rock.
130. Thin bedded layers of rock.
126. Bottom of ledges of rock.
90. Top of main cliff composed of dark grey and mottled layers of rock.

63. Top of main cliff composed of dark grey and mottled layers of rock.
55. Same, slightly inclined.
50. Beds in confusion near line of the fault.
Thin concretionary beds of blue limestone on the south side of the fault, probably equivalent to those nearly three hundred feet above Kentucky river, on the north side of the disturbance.
0. Low water of the Kentucky river.

The summit level here is about four hundred and thirty feet above the river.

The rounded cliffs of thick bedded rocks, seen on Howard's creek, near our route to Winchester, are mostly schistose in their structure, with but very few marly partings. The best grass lands of this country are in the north part, adjacent to Bourbon, and the northwest part adjoining Fayette. The thinnest lands are in the southeast part towards that part of Red river dividing this county from Estill; here there is a small area based on the black slate.

On the lower part of Howard's creek there are some beds of magnesian limestone, interstratified with the Kentucky river marble, about one hundred feet above the river, which make excellent durable building stones that work well under the chisel. They are mostly of a fine buff color, and the strata yields dimension stones of from eight inches to three or four feet. The bottom layer, which is variegated, is from eighteen to twenty-two inches; the two top layers are from eight to twelve inches; over these are some white layers, about sixteen inches thick; these latter are not durable stones.

The second and third layers are considered the best by the stonecutters. When first quarried these rocks are soft and easy to cut, but harden by exposure, a property which is highly advantageous in materials for construction.

Two varieties of soil have been collected for analysis from this county; one set from Judge Simpson's farm, in the northern outskirts of Winchester, where the growth is black walnut, locust, chincapin, oak, elm, and mulberry. The original undergrowth was cane, which grew very luxuriantly. The nearest underlying rocks are the Leptæna shell beds of the blue limestone. The other variety was taken from Squire Duncan's stock farm, in the northwest part of the county, where the growth is sugar-tree, black locust, black walnut, white and

black ash. The nearest underlying rock is a bluish-grey variety of Chætetes limestone.

JESSAMINE COUNTY.

Seventy feet of blue limestone are exposed above the bed of Hickman creek, below Robert Smith's house. At forty feet the beds are of a concretionary character. The spring issues from beneath the *Orthis testudinaria* beds. Just above the beds of Hickman creek a stratum of the blue limestone shows itself, rich in *Pleurotomaria*, which are not in a good state of preservation—probably *P. bicincta?* The *Leptæna alternata* is also abundant.

Below the dam at Paton's mill, on Hickman creek, the upper layers of the Kentucky river marble are exposed.

One of the sets of soils collected for chemical analysis in Jessamine county—Nos. 664 and 665—was taken immediately over the *Orthis testudinaria* beds of the blue limestone, which are sixty-seven feet above the cherty layers overlying the Kentucky river marble. The growth is shell bark hickory, and overcup, white and red oak, black ash and black walnut; red-bud and dogwood was formerly the principal undergrowth, but it is now nearly cut away.

The best soil of Jessamine county lies north of Nicholasville, over the fossiliferous beds of the blue limestone; that which lies to the south, over the chert beds and the Kentucky river marble, is not so good. A soil was also collected over the upper bed of this latter formation, about two and a half miles north of the bridge over the Kentucky river, four hundred feet above that river, and is reported in this volume in the chemical section, Nos. 662 and 663.

The following section was obtained in the cut for the turnpike, and below the bridge over the Kentucky, in the southern part of the county:

483. Summit of turnpike, two to two and a half miles from the bridge.
480. Beds of the blue limestone containing Orthis testudinaria, with small variety of *Chætetes lycoperdon*.
400. Top of the Kentucky river marble near where the soil was collected over that formation.
396. Cherty beds of mottled grey limestone.
382. Grey close textured brittle limestone, with soft porous chert.
367. Same, weathering white on the surface.
358. Same, cherty and mottled bluish grey.

353. Same, with cherty layers.
348. Grey brittle close textured limestone.
339. Buff magnesian limestone, (good building stone?)
334. White brittle limestone, weathering with rounded edges.
330. Light grey brittle limestone.
325. Same, somewhat crystalline.
320. Grey brittle limestone, somewhat crystalline.
300. Grey limestone, rather concretionary.
288. Grey coralline beds, mottled with buff where oxidized around the place of the fossils.
278. Same bed.
268. Tabular layers weathering rough, with light colored earth in the interstices.
259. Same, very white on the exposed surface.
245. Same, weathering rough.
236. Same, weathering rough.
231. Smooth textured limestone, with red clay.
222. Top of mural escarpment, with cedar growth, and red clay intermixed with rock.
213. Base of same.
212. Marly beds between two benches of rock.
307. Top of second bench or escapment on the turnpike.
192. Layers from a few inches to one foot weathering into cavities.
183. Top of heavy bedded limestones, two to three feet in the bedding, and junction with marly decomposing layers.
173. Thick bedded Kentucky river marble.
169. Layers somewhat concretionary.
165. Thin layers of one, two and three inches.
160. Compact close textured limestone, with marly partings between the layers.
155. Thick bedded rock, forming a mural face on the turnpike.
143. Layers with small spiral univalves.
138. Grey beds of limestone of three to fourteen inches.
133. Layers from one to nine inches.
125. Layers from one to nine inches.
120. Schistose beds of close textured rock.
110. Main mass of breccia and calc. tufa on the slope.
85. Debris of chert, tufa, and reddish earth.
76. Platform of quarry rock near entrance to the bridge.
62. Coralline limestone of the Kentucky river marble series, near the level of the bridge.
51. Base of mural face of same, below bridge.
15. Bed containing minute corallines? under the bridge.
0. Lowest coralline beds, near low water of the Kentucky river.

The numbers in this section represent the heighth at which the different members of the Kentucky river marbles and overlying blue

limestone, up to its testudinaria bed, are found above the Kentucky river, in Jessamine county. In estimating the thickness of the individual members the spaces are liable to small corrections, for a slight northerly dip which is nearly in the direction the levels were run.

In the nearly verticular escarpment which rises abruptly from the Kentucky river, on the north side, to the top of Boone's Knob, we have an absolute thickness of two hundred and forty-four feet of light grey, dove-colored and mottled limestone, embraced in the so-called Kentucky river marble series, which does not however embrace this entire group of rocks, which must be somewhat over three hundred feet in thickness in this part of its range.

GARRARD COUNTY.

The northerly dip spoken of on the north side of the Kentucky river is connected with a remarkable fault and dislocation of the strata, from a quarter to a half a mile south of the bridge, which brings the O. testudinaria beds abruptly down within one hundred and twenty feet of the river, and on the same level with those members of the Kentucky river marble series, which occur in the section on the north side of the river at about the same height, showing a fault and subsidence of the strata, on its south side, of three hundred and fifty feet, marked by a deep gorge running nearly east and west. Immediately adjoining this fault the strata of the blue limestone on the south are much broken, and have tumbled in confused masses into the gulf; but the marble rock, on the north, stands in a solid wall; still the dip, a very short distance beyond the dislocation, has only been slightly reversed to the southwest.

Though the termination of the ravine, where this disturbance is best seen, appears to run nearly east and west for the short distance traced, the actual general course of the fracture is, in all probability, northeast and southwest, and if so, is a continuation of a corresponding fracture subsequently seen on the north side of the Kentucky river, in the edge of Clarke, opposite Boonesboro; and this line of fracture is, in fact, the southeast wall of the great uplift of the lowest fossiliferous rocks of central Kentucky, and the base of an obtuse triangular area marking this protrusion, which has its depressed apex somewhere in Franklin county, in the valley of the Kentucky river, below Frankfort, and the corners of its elevated basal angles, the one in Boyle

county, not far from Perryville, and the others not far from the edge of Clarke and Montgomery counties, near Kiddsville, on Lulbegrud creek. The principal great south bend of the Kentucky river, forming the boundary between Madison, Garrard, and Jessamine counties, has, no doubt, been deflected around the face of this great uplift, which has not only impressed its topographical configuration on the face of the country, but its geological and agriculture features. This triangular area is coincident with the out-crop of the so-called Kentucky river marble, rising in bold escarpments of two hundred to three hundred feet, the bluffs of the Kentucky, along the whole course of this southern bend, but partially concealed towards the north, except where the streams have cut several hundred feet beneath the general surface of the country.

It is this disturbance which has burst asunder the newer rocks, and cast them off to the southeast and southwest, and the same movement, together with the subsequent effect of denudation, has given the present peculiar form to the bearings of the black Devonian shale and knob formation, the western limb of which, from its northeasterly bearings from the southeast corner of Monroe county, through Cumberland, Russell, Casey, into Lincoln, is abruptly turned back on its course, a little south of Stanford, in a short curve south of west, and then conforms in its out crop with the valley of Salt river, at first in a long west curve, and then with a northwest bearing to the Ohio river; while the eastern limb preserves its northeast course, with only some slight undulations, until it reaches the Ohio river, in Lewis county, opposite the valley of the Scioto.

Southwest of the point of great divergence, in Lincoln county, of these rocks of Devonian and subcarboniferous date, the older strata of the Silurian period are contracted into a narrow zone, sometimes almost concealed from view in its narrow linear axis, by the overlapping superior strata, and only fairly exposed to view in the deep cuts of the vallies; whereas, north of this axis of greatest disturbance, the strata of Silurian date are spread out over a large area, embracing about one-third the entire state, from the valley of Salt river on the west, to that of Tygert on the east, and from the Ohio river on the north, to the heart of Lincoln, Garrard, and Madison counties on the south, including, within their boundary, the most productive agricultural region of the state.

Sulphate of barytes has been found in this part of Garrard county. It is probable that a vein similar to that described on Grier's creek, in Woodford county, and North Elkhorn, in Franklin county, occurs here also, in connection with the above described axis of disturbance.

To the south of the ravine marking the place of the fault, and twenty-five feet above it, the *O. testudinaria* beds are in place, dipping slightly to the southwest; and ten to fifteen feet higher beds of the blue limestone occur, charged with *Murchisonia bicincta* and *gracilis*, *Endoceras proteiforme*, a large *Bellerophon* and *Bucania* of Hall, probably of undescribed species, with other fossils.

Two arched waves of dip are visible between this and the toll-gate. Towards the top of the hill the beds of the blue limestone are thin and schistose, with marly partings, and full of branching forms of *Chætetes* and *A. modesta*, the whole covered by vestiges of the silicious mudstone, stained with oxide of manganese on the surface.

Between this place and Bryantsville the growth is chiefly oak, mixed with some beech, sugar-tree, poplar and buck-eye.

One mile and a half southeast of the forks of the Lancaster and Danville turnpikes, the country and the soil is much diversified by an outlier of the knob formation, known as Burdett's knob. On the north side of this knob the strata of hydraulic limestone, underlying the black slate, are tilted at an angle of 15° to 19° in a direction south 40° to 50° west, and several varieties of mineral water ooze from a line of fault between these strata and rocks of Silurian date. One of these is a very astringent water, strongly impregnated with sulphate of alumina and protoxide of iron, so much so that both persons and cattle have suddenly died from drinking it.

There is also a dislocation of the strata on the south side of this knob, between which lines of fracture the whole strata have subsided, bringing the hydraulic limestone almost in juxtaposition with the upper beds of the blue limestone; the consequence of which is, that around this knob the most abrupt changes of soil are perceived, in a few rods, from the most productive mulatto soil to the cold spouty clay lands, or to a poor silicious soil; but these latter are only confined to narrow belts around the base and slopes of Burdett's and Richardson knobs. These knobs are from one hundred and seventy to two hundred feet above the general surface of the surrounding country. In some places the black slate appears almost on edge.

In the well sunk at Mr. Hoskin's, at the forks of the turnpike, a very white calcareous rock was passed through, under strata of the blue limestone. The water of this well was tested, and found to contain,

Bi-carbonate of lime;

Bi-carbonate of magnesia;

Sulphate of soda;

Sulphate of magnesia.

On the blue limestone around Hoskin's, where the sample of soil was taken for chemical analysis, the growth is white and black walnut, wild-cherry, black and honey-locust, sugar-tree, hackberry, shell-bark hickory, poplar, overcup oak, buckeye, and mulberry. The nearest underlying rock is blue limestone, with cherty segregations, containing *A. modesta* and *O. plicatella*, underlaid by thicker beds of a grey sub-crystalline limestone, which has been used for metalling the road.

This outlier of black slate and knob freestone lies at least twelve miles north of the general boundary of that formation. The general level of this part of Garrard county is about four hundred feet above the Kentucky river, and the top of Burdett's knob about six hundred feet.

At J. T. Hoskin's a subterranean spring is said to flow, in a cavernous channel of limestone, some twenty feet under the surface.

Immediately around Edmund Smith's house the growth is poplar, sugar-tree, beech, with some hickory, but about a quarter of a mile to the south, white oak, abundance of dogwood, and beech. At James Dunn's, white poplar, beech, sugar-tree, and white oak. Across Scott's branch, hackberry, a little black and white walnut, and wild cherry. On the knob, beech and chesnut-oak, and over the hydraulic limestone, white oak and ash. All this diversity of growth, over a limited space, is accompanied by a corresponding variety in the soil. On the hill land, where the silicious mudstone is in place, near W. Robinson's, there are numerous large yellow poplar, beech, sugar-tree, and white and black ash. The soil here, in a wet time, is sticky and tenacious, and subject to extensive slides; but it is very good wheat land. The section of the rocks from the general surface of the country down to the level of Dick's river, on the edge of Garrard and Boyle counties is as follows:

275 to 280. General level of the upland farming lands

240. First out crop of blue limestone.

215. Grey semi-crystalline limestone, with cherty fragments.
210. Earthy beds of blue limestone.
200. First layer of white compact "Kentucky river marble" or "birds-eye limestone," alternating with bluish grey limestone.
195. Do. softer and liable to disintegration.
185. Do.
173. White brittle marble rock.
155. Do., weathering in cavities and channels.
150. Do.
145. Grey bed, with corallines in relief.
Slope, with rocks concealed.
117. Grey and somewhat semi-crystallinelimestone.
115. Do., weathering with rounded edges.
110. Grey brittle marble rock.
107. Mottled marble rock.
105. Do., rather darker in color.
Lighter colored do., eight inches in the bed.
100. Buff buildingstone, mottled with grey.
94. Buff buildingstone, four feet in the bed.
90. Light grey marble rock.
85. Do., rather lighter in color.
80. Marly intercalations.
75. Base of bench of marble rock dipping easterly.
65. Hard brittle mottled marble rock.
64. Do.
55. Marly layers, decomposing in the slope.
50. Light colored brittle marble rock.
45. Do. greyer,
30. Do.
27. Do.
20. Do. hard mottled grey and white.
15. Do.
10. Do. weathering rough.
5. Coralline bed, weathering into rough impressions like birds tracks.
0. Semi-crystalline layers in bed of Dick's river, in layers of three to four inches.

There is a slight easterly dip of the rocks here, which will slightly modify the absolute thickness from the spaces in the preceding section.

MERCER COUNTY.

In the bluffs of Mercer county, below Shakertown and the High Bridge, at the crossing of the Lexington and Danville railroad, by the mouth of Dick's river, the "Kentucky river marble" ("birds-eye

limestone") attains as great an elevation as I have yet found it in Kentucky, viz, 208 feet in the following succession:

456. Level of Main street in Shakertown.
385. Concretionary thin shell-bed of the blue limestone formation.
382. Chætetes layers.
353. Do.
345. Loose chert fragments.
317. Chert and close-textured marble rock alternating.
308. Top Kentucky river marble in well developed layers.
304. Level top of the main cliff of same formation on opposite side of gorge.
300. Cliff under the abutments of High Bridge.
290. Marly layers.
281. Bench of irregular bedded limestone, weathering rough, below base of abutments.
270. Do.
265. Marly layer about one foot thick.
262. Top of solid bed of ("birds-eye") marble rock eighteen inches thick.
254. Crumbling marly bed.
243. Tubular layers mottled grey and reddish grey.
240. Solid bench of limestone, weathering schistose.
230. Grey marble rock.
220. Solid bench of do., weathering with a rough surface and schistose structure.
210. Buff (magnesian?) limestone intercalated.
200. Marble rock in thick beds.
195. Thin bedded limestone.
190. Marly clay.
175. Beds, thin above and thickening below, from three to eight inches.
170. Marble rock.
160. Do.
155. Do. weathering in holes.
Turn of road.
150. Bench of marble rock in beds from two inches to one foot.
135. Bottom of schistose layers four to five feet.
95. Top of marly layers.
90. Bottom of do. between heavy beds of marble rock,
70. Heavy bench of marble rock.
68. Base of exposure on the south side of the Kentucky river, ten to twelve feet above high water mark.

Lower rocks concealed on south side of the Kentucky river.

In the bold escarpments of the Kentucky river, at the mouth of Dick's river, some of the best exposures of the lowest limestones of Kentucky are presented to view, in the romantic cliffs of marble rock,

that here hem in both rivers in the deep gorge over which the suspension bridge of the Lexington and Danville railroad is to make its fearful span of twelve hundred and fifty feet, at an elevation of nearly four hundred feet above the bed of the Kentucky river, which, when completed, will form one of the noblest structures built by the skill and ingenuity of man.

A line, running nearly centrally through Mercer county from north to south, divides this county into two distinct agricultural regions. To the west of this line the growth is white and black oak, hickory, sugar-tree, dogwood, and some poplar. The soil is, for the most part, shallow near the rock, especially where the small straight ash grows, but yet productive. To the east the prevalent growth is sugar-tree, ash, black, and white walnut; this is, emphatically, the blue-grass region of Mercer county. The southeast part of the county is somewhat broken; it supports a heavy growth of white and black oak. The underlying rock is near the junction of the blue limestone and Kentucky river marble.

A soil was collected, characteristic of the eastern part of the county, from Col. William Thompson's plantation, where the growth is black and white walnut, thick shell-bark hickory, white oak, ash, and wild cherry. The result of the analysis of this soil will be found in the Chemical report, Nos. 678, 679, 680.

Small quantities of lead ore, associated with sulphate of barytes, have been found in veins traversing the Kentucky river marble rock, near the mouth of Shawnee Run; also, higher upon the same stream, in digging the foundation for a mill built by the Shakers, but hitherto the quantity has been too small to warrant regular mining operations. These metallic lodes are, no doubt, connected with the great axis of disturbance previously spoken of. The junction of the Kentucky river marble rock and the overlying members of the blue limestone, seems to be marked in this county; and, indeed, almost universally where the passage from the one rock to the other is visible in Kentucky, by intercalated seams and segregations of chert, indicating a precipitation or deposition of silicious material from water during the period of transition from one group of rocks to the other. These cherty masses can be seen prevailing to a considerable extent along the divide between the waters of the Kentucky and Salt rivers, from Harrodsburg to Eldorado, marked by a growth of white oak and mockernut hickory, usually denomina-

ted black hickory, *Juglans tomentosa*. Where the soil is more calcareous and less silicious, white and black walnut prevail, interspersed with sugar-tree and white and blue ash, as in the vicinity of the locality where the soil was collected for analysis. This soil is very much improved by turning in red clover, especially for a succeeding growth of hemp.

At the crossing of Salt river, on the Harrodsburg and Cornishville road, the rock is coarse-grained, heavy bedded, sub-crystalline limestone, lying near the junction of the blue limestone with the Kentucky river marble. About twelve feet is exposed containing few or no fossils.

Soils Nos. 68, 682, 683, and 684, of the Chemical report, were collected from the western part of this county, near Cornishville; growth white and red oak, sugar-tree, black walnut, dog-wood. This soil lies generally close to the rock, and produces much better than the appearance of the rocky ground would lead one to suspect. The chemical analysis shows it to be a soil rich in the mineral fertilizers, and capable of easy restoratien—the sub-soil and under-clay being stronger even than the surface soil. No. 681 is remarkable for containing the largest quantity of saline ingredients, soluble in carbonic acid water, of any soil yet examined.

The ridges are often dry, yet water is frequently reached fifteen to twenty feet below the surface; and it is seldom necessary to dig more than twenty-five feet before water is obtained, even in localities where it was previously supposed that it would be necessary to go forty to fifty feet.

Even in this, apparently shallow soil, deep ploughing and sub-soiling has proved beneficial, especially after the under-clay has been sometimes exposed to free access of air. The stiff under-clays, often thrown out in digging wells, disintegrate rapidly, and always contributes fertility to the spots on which they may have been distributed.

The most superficial beds of the blue limestone, in this part of the county, are those containing *Chætetes, O. testudinaria, and A. modesta*. In the earthy beds of this formation, near the confines of the county, some crystals of fluor and calcareous spar occur, near the junction of these strata with the underlying marble rock.

WASHINGTON COUNTY.

On the high grounds, between the waters of Chaplin's fork of Salt river and Glen's creek, the silicious mudstone is visible, interstratified, however, with limestone; while, on the slopes beneath, fine slabs of the *Leptæna sericea* are abundant. There appear to be two horizons of silicious mudstone or mudstone shales, some layers intervening between the sericea beds of the blue limestone and the place of the Utica and Hudson river graptolite shales of New York; the other layers lie some two hundred to two hundred and twenty-five feet higher in the blue limestone, over the principal bed of the *Leptæna alternata*, and under the horizon where the *Orthis lynx* is most abundant; the latter are usually thicker, better developed, and impress a more decided feature on the country than the lower, thinner and less characteristic layers. Those cited in the hills above Glen's creek belong to the lower group.

The general character of the country, on the northeast part of this county, is much the same as that described in the adjacent western part of Mercer county. Land broken and rocky, but still productive, often yielding from fifty to sixty bushels of corn to the acre in favorable seasons. The general experience of the farmers of this part of the county is, that deep ploughing greatly improves the yield of the land, since the farmer who pursues this course often doubles the crop over that of his neighbor who ploughs shallow.

The agriculturalists who reside in this part of the county would do well to try the grape culture on the steep hill sides, liable to wash by frequent ploughing. Vineyards are probably the most profitable application of such land, under judicious management. The making of wine is a much more simple operation than is usually supposed in this country; the main requisites are cool cellars, and the strictest attention to the cleanliness of everything used in the process of preserving and fermenting the juice. The expressed juice must be received into clean barrels, and allowed to ferment in a cool celler. When the fermentation has ceased the air must be excluded, and the barrel and its contents kept as cool as possible. This is even more requisite now than during the fermentation. It is not necessary to add any sugar, though some wine-makers prefer separating the first expressed juice from the last product, to which they add a certain portion of sugar, and make from it a sweet wine, while from the first pressings either a dry wine

may be obtained, or a sharp sparkling champaigne wine results, by simple fermentation, without addition of sugar. The latter sparkling wine only requires to be bottled up before the last portions of carbonic acid have had time to escape; this gas is condensed in the wine and gives it the sparkling head. Age improves wine by the gradual change which the etherical oily principles undergo, which improves their flavor; hence the high esteem in which old wines are held, and the increased price at which they are sold.

About Mackville and Williamsburg there is some excellent tobacco land, supporting a growth of poplar, mixed with beech, sugar-tree, ash, and hickory; this land is better for corn than small grain, and some portions of it yield good hemp, blue-grass, and clover, especially where it is underlaid by a mulatto colored clay. For the chemical analysis of this soil see Dr. Peter's report, Nos. 773, 774, and 775.

On the high ground, near Long Lick branch, the rocks are beds of blue limestone, alternating, with a buff earthy mudstone, underlaid by grey and bluish argillo-calcareous and sub-crystalline limestone.

The country in the Pleasant Grove settlement, near the center of the county, is remarkable for the large size of its yellow poplars, and the quantity of pawpaw undergrowth. The soil is good hemp land, but tobacco grows too coarse and rank; better for corn than wheat. It is superior land to that about Springfield.

Mr. E. C. Brown informed me that in clearing some of his land he cut down gigantic yellow poplars, that were nine feet in diameter; out of *one* of these trees five hundred and thirty rails were split, and stuff enough besides procured for two still tubs. Nos. 770, 771, and 772, of chemical sectios, show the composition of this soil, which will be seen to be quite rich in phosphoric acid, with a large proportion of its saline matter soluble in carbonic acid water.

There is a strip of this kind of land which extends from the Beech Fork of Salt river, where it is about three quarters of a mile in width, but gradually expanding as it proceeds, in a northerly direction. It is bounded on either side with white oak land of inferior fertility.

The rock which is taken from the well sunk at Mr. Brown's, on the above mentioned poplar land, is a bluish argillaceous limestone and marlite, containing *O. lynx* and *subjugata;* the peculiarity of the soil is due, no doubt, to the character of the underlying rock, which is of

a different lithological nature from the rock containing the same fossils in Bullitt and Spencer counties.

Associated with these large poplar trees are large white and red beech, white and black ash, pig-nut, and shell-bark hickory, mixed with pin-oak; on the heads of the hollows, hackberry, coffee-nut, buckeye, and very large sugar-tree. Similar land extends from the Knobs on the edge of Marion and Boyle, through part of Washington, Nelson, Spencer, Shelby, Henry, and Trimble to the Ohio river, following, no doubt, the out-crop of the same geological formation. This strip of land is narrow at its southern commencement, but gradually expands in its northern extension, bounded on the northeast by a white oak country. Red clover grows very luxuriantly on this land, and blue-grass, orchard, and timothy succeed well on it. Hitherto but very moderate crops of wheat have been raised on it, but, with a proper mode of culture and preparation of *old* ground, there is no doubt but much larger crops might be raised. The reason why wheat does not succeed well in this *new* ground is, probably, on account of the too great abundance of soluble salts, which causes it to run too much to straw. It is for this reason, too, that notwithstanding the continued succession of crops of corn, from ten to twelve years together, grown on some of the fields, to supply the numerous distilleries that formerly existed in this county, its fertility is even now but very little impaired.

It is worthy of note that the sub-soil contains, in many places, "shot iron ore," particularly under the blacker and lighter varieties; there are also nests and veins of gypsum in the blue argillaceous limestone, taken out of the excavations for wells; the former, no doubt, imparts its principles locally to the soil; the latter is probably too deep-seated to exert much influence, for the analysis of this poplar soil does not show any more sulphuric acid than many of the other soils.

The underlying beds of blue limestone seem to conform to the contour of the country, as it is reached, nearly at the same depth, in low and high situations.

Samples of soil were also collected for chemical analysis from the whole oak land bordering on these poplar lands, from Wm. Lynton's farm, on the southwest side of the Beech Fork of Salt river. This soil is esteemed better for wheat than the poplar and beech land just mentioned. The chemical analysis of this soil is given in the Chemi-

cal report, under the head of Washington county, Nos. 773, 774, and 775. The result confirms the inference in regard to the reasons of the comparative small crops of wheat raised on soil No. 770; the soluble saline ingredients in this white oak land are only about one half in quantity.

The white oak timber on this land is interspersed with sugar-tree, scaly-bark hickory, walnut, honey-locust, some red oak, and a fine black ash, but no blue ash.

These sets of soils—Nos. 773, 774, and 775—will give a correct idea, not only of the famous white oak land, on the southwest side of Beech Fork of Salt river, in Washington county, but of a portion of the same quality of land in Marion county. It is derived from the Chætetes and shell beds of the blue limestone, which underlie this white oak country, as exhibited in the following section obtained on Beech Fork of Salt river:

180 to 210.	General level of the upland farming land.
150.	Earthy decomposed material.
125.	Earthy decomposed material.
100.	Same, with O. lynx.
75.	Same, with O. lynx.
55.	Chætetes limestone.
40.	Earthy calcareous rock perhaps not in place.
35.	Leptæna alternata beds of limestone.
0.	Low water of Beech Fork of Salt river.

The white oak soil derived from this formation is regarded by some but little inferior to the best soils of the blue-grass country. It may be so for certain crops of small grain, but the comparative chemical analysis would not justify this assumption for corn and grass crops generally.

The lynx beds of the blue limestone are also everywhere seen along the Danville turnpike, in the neighborhood of Dr. Hughes' farm, and about Janes' mineral spring of which the analysis is elsewhere given. In the descent of the road to Glenville, on Chaplin creek, more earthy textured layers are seen under the lynx beds, which afford a buff-colored soil. The rocks dip here at an angle of 2° to 3° to the southeast. These earthy beds are, in texture, much like the graptolite rock near the water works at Cincinnati, but none of these fossils were found in it here. Associated with these are thin bedded limestones, interstrati-

fied with marly shales, containing *O. testudinaria*, *Leptæna alternata*, and *fucoides?*

NELSON COUNTY.

On Chaplin creek, which divides this county from Washington, the following section was obtained, showing the members of the blue limestone underlying the northeastern part of Nelson county and the adjacent portion of Washington—dip 2° to 3° to the southeast:

110. Chætetes and shell beds of the blue limestone.
100. Buff silicious mudstones.
95. Leptæna limestone.
90. Grey hydraulic-looking earthy limestone.
74. Shell and coralline beds of limestone.
70. Grey silicious mudstones.
63. Brown silicious mudstone.
60. Intercalated limestone.
55. Silicious mudstones.
Do. with marlites.
32. Encrinital and Leptæna limestone.
30. Indurated ash-colored marl.
0. Low water of Chaplin creek.

I have already had occasion to remark that the only region I had yet found, in the blue limestone formation, where deep ploughing and sub-soiling had failed to benefit the land, was in Nelson county, on Mr. N. Beauchamp's farm, on the waters of Chaplin creek. This gentleman informed me, when I met him in Frankfort, in the winter of 1855, that he had sub-soiled a portion of his land in 1844, which, instead of improving its productiveness, actually diminished its fertility, from which it had not yet recovered, and requested me, when passing through Nelson county, to call and examine the country, to see if this remarkable exception to the experience elsewhere in the adjoining counties could be explained by science. Accordingly, when making a geological reconnoissance of this county, in August of 1856, I examined the tract of land in question, and collected samples of both the virgin soil from the woods pasture, and from the field adjoining, which had been sub-soiled with so remarkable a result—taking a portion, both of the soil, sub-soil, and under-earth. The analyses of these have, I believe, been completed, but not fully reported; they will probably appear in Dr. Peter's report in the third volume. I understand, however, verbally, from Dr. Peter, that he has found the sub-soil of the

field in question deficient in the mineral fertilizers compared with the surface soil. The geological explanation of this result is no doubt afforded by an inspection of the foregoing section on Chaplin creek. The soil has been derived chiefly from the chætetes and shell limestone, shown in that section at one hundred and ten feet, while the sub-soil has probably been produced from the disintegration of the underlying buff silicious mudstone, which is, in fact, a similar rock to that which I found out-cropping on Mr. Beauchamp's farms, on the nearest slopes, alternating with limestone. On an average it is ten feet down to the solid limestone, which appears to be the bed represented on the section at ninety-five feet. The soil, or rather under-earth, which overlies this limestone is, according to Mr. Beauchamp's experience, hurtful, rather than beneficial, to vegetation, when mixed with the surface soil; this has evidently been derived from intercalated beds of silicious mudstone; but when the analysis of the soil, sub-soil, and under-earth is fully set forth it will, undoubtedly, speak for itself, and we shall then be able to draw more definite conclusions. The immediate sub-soil which is grey, light and porous may allow water to filter too rapidly through it, but it is underlaid by eighteen inches to two feet of a more retentive material, in which alumina appears to be more abundant, and, if so, is undoubtedly richer in some of the earthy and alkaline bases than the immediate sub-soil.

It is probable, from the loose and porous nature of the sub-soil, that this land, does not stand drought, but yields well when there is abundance of rain during the summer.*

On the 1st of July, in the year 1854, corn on this land was nearly as high as a man's head, but after the drought set in, in that month, it made but little progress in its growth, and hardly any corn was made that year on it. The virgin soil, above this grey stratum of sub-soil, produces, in seasonable years, one thousand pounds of hemp to the acre, seventy to eighty bushels of corn, and twenty-five or even over thirty bushels of wheat.

Since the above was written Dr. Peter has reported in full on the Beauchamp soils. They will be found in his Chemical Report, under the head of Nelson county, numbered 714, 715, 716, 717, and 718, with remarks by himself on their properties. In addition to his con-

*Some of the farmers contend that this land stands drought better than the blue ash land.

clusions I would here observe, that comparing the analysis of No. 714—the virgin soil, and that of the old field—with that of 716—the sub-soil—that the latter has proved to be poorer, both in alumina, oxide of iron, lime, magnesia, phosphoric acid, sulphuric acid, potash, and soda—in every one of the essential bases and acids of the inorganic food of plants—while it has a larger proportion of sand and silicates. The case holds good also in comparing the soil of the old field—No. 715—with the sub-soil of the same, No. 716, except in the case of alumina and oxide of iron. If then this sub-soil be mixed largely with the surface soil it will, undoubtedly, diminish the amount of particles in a given space capable of affording nourishment to the plants, hence it will not prove beneficial until the proportion of the above bases and acid have been reduced, by frequent cropping, below the standard of the sub-soil, when its good effects would then certainly become apparent. The earth, No. 717 of the Chemical Report, is richer in alumina, oxide of iron, lime, magnesia, potash, and soda than even the virgin soil, and falls but little short of it in the amount of phosphoric and sulphuric acids. I cannot help suspecting, from an inspection of its analysis, that if Mr. Beauchamp will give this under-earth a fair trial on his *oldest* land, that he will find it acts beneficially, instead of injuriously, on his crops. The shell-earth, (No. 718,) of the Chaplin fork, though somewhat similar in appearance to the shell-earth underlying the blue ash lands of other parts of Nelson, has not proved to be, by analysis, as rich in the mineral fertilizers; but even this earth, under certain conditions of exhausted land, can hardly fail to be without its beneficial results. The reason why the soil of the Chaplin fork does not stand drought well is no doubt to be accounted for, in part at least, by the comparatively small proportion of *soluble* saline extract which it yields to carbonated waters.

The predominating growth on this soil is beech, some of the trees four feet through, mixed with large sugar-tree, black and white ash, and walnut; undergrowth mostly dogwood. Beech is about ten times as abundant as the other growths.

In sinking wells the first solid rock met with is, as has been stated, usually ten feet from the surface; at twenty feet a bluish limestone is reached, which is probably the second bed of shell and coralline limestone shown in the section at seventy-four feet; but, as the dip of the rocks is considerable in this neighborhood, and the section given is

some distance from the Beauchamp farm, I cannot speak with absolute certainty as to the identity of these beds, until the detailed survey supplies more numerous sections of the strata underlying the northeast part of this county. There is also a light loose soil in the bottoms of Chaplin creek, which stands drought even worse than the upland soil above mentioned; this has, undoubtedly, been derived from the washing of the silicious mudstones, so prone to disintegrate at their out-crop on the adjacent slopes. Hemp grows tall and coarse in this land, but not of the fine quality produced in Woodford; in 1842 as much as one thousand two hundred pounds was raised to the acre; the tobacco plant grows, also, too coarse. That there must be a considerable proportion of silica in these soils is proved by the fact that the plough scours and runs easily, especially in the sub-soil; but yet it is not palpable sand, visible to the naked eye, in the crude unwashed condition of the soil, as you see it in the field. Vegetation progresses slowly at first on this land, but advances rapidly in June and July if there are seasonable rains.

The sub-soiling seemed to be less injurious to wheat than to other crops; in 1849 the sub-soiled field yielded twenty bushels to the acre of medalesianian wheat. Hemp has not been tried on the land, since it was sub-soiled; clover does not thrive well on it since, and the stalks are disposed to turn red.

The quality of soil which has just been described only extends about two miles to the north, three or four to the south, with a width of from three to four miles east and west. It is bounded on the east and west by white oak land, and by the blue ash land on the north and south.

The friable shell earth, No. 718, shows itself on the slopes wherever the rains and cuts have exposed the lower strata, under the sub-soil.

Further to the northeast, on the waters of Ashes creek, the stratification is very similar to that on Chaplin creek, but the soil seems to be more retentive, and there are larger oaks and less ash than around Beauchamp's. In this vicinity Mr. N. G. Thomas ploughs, in many instances, eight to ten inches deep, with good effect; though he has never regularly sub-soiled his land. Mr. McGraws, in the same neighborhood, thinks that in some portions of this part of Nelson, sub-soiling has rather a tendency to bake the land; but Maj. Minor has sub-soiled with good effect; and Mr. Duncan has used the bull-tongue with advantage, but this is on the blue ash and sugar-tree land.

The soils, sub-soils, and under-shell-earth, Nos. 720 to 725, inclusive, are all characteristic of the famous "blue ash lands" of Nelson county. The chemical analyses places them amongst the most fertile soils derived from rocks of Lower Silurian date. Nearly the whole of the blue ash region is under-laid by a shell earth full of silicified *O. lynx*, which, being of more durable material than the earthy calcareous matrix, have remained often entire, while the rock has crumbled to a friable earth—this is No. 723, of the Chemical Report. It is remarkable for the very large amount of phosphoric acid which it contains, exceeding in this—one of the most important elements of fertility—any one of the two hundred and two soils and sub-soils analyzed up to the present time, and derived, no doubt, from the numerous fossil shells with which the original rock was charged. The alkalies, too, are in large proportion. A soil with such a foundation, which often lies within reach of the sub-soil plow, if judiciously managed, ought to remain for centuries but very little impaired in its producing powers.

The principal and only disadvantage in some of these soils is, that being loose and friable they are not very retentive of moisture, and hence the crops are apt to suffer in times of drought.

No. 719 of the Chemical Report is also from Nelson county, but is derived from the magnesian limestones, of Upper Silurian, date characterized by *Calymene Blumenbachii*. It is of a very different character from the other soils examined from Nelson, as may be observed by consulting the Chemical Report.

Shell earth of similar appearance to No. 723 was found, almost universally underlying the soil at greater or less depths throughout the region of the blue-ash lands of Nelson county. This earth is probably derived from a higher stratum, geologically speaking, than any of the beds shown in the Chaplin section. The nearest underlying solid rocks observed in this part of Nelson county are bluish-grey subcrystalline limestones, in beds from three to five inches in thickness.

Near the heads of Simpson creek, in the vicinity of R. B. Grigsby's, the previously mentioned friable shell-earth is seen in great perfection, underlying the soil. This land is regular blue ash land. It is a light dry soil, excellent for corn, wheat, and rye, but not so good for hemp and tobacco; the latter grows too coarse; it does not stand drought so well as some of the more retentive soils. There is much more iron in the sub-soil than on Chaplin creek.

In the early settlement of the country there was a luxuriant growth of cane; the undergrowth at present is spice and pawpaw; some portion of this country had formerly also a thick growth of peavines, especially about "Burnt Station."

The blue ash land, with its underlying shell earth, was traced all along the Bardstown road nearly to the farms of Ellis Duncan and Arch. Wilson.

The color of the soil and sub-soil in this part of Nelson county indicates more iron in the soil and sub-soil than near Bloomfield, and the latter is more tenacious and retentive than the sub-soil on Chaplin and Ashes creek; hence it is colder and slower, but better adapted for wheat, and the crops do not suffer so much from a drought, and there is more oak growth interspersed with the ash, sugar-tree, walnut, and hickory. Deep ploughing is here decidedly advantageous, but the benefit is not seen so much the first year as in the second and third years.

Much of the water collected in the wells of Nelson county, around Bloomfield, as well as that which rises to the surface through the beds of the blue limestone in the same vicinity, contains more than the normal proportion of common salt; indeed, in former times, some salt has been obtained by boiling down the weak brine obtained on the east fork of Simpson's creek. There are, moreover, in the vicinity of Bloomfield, several mineral waters, which were tested at the fountain head, the results of which are recorded in the third chapter of this report, under the head of "mineral and well waters."

The following section was obtained on Withrow's run:

130. Ledges of buff magnesian limestone of the Upper Silurian Period containing *Calymene Blumenbachii.*

120. Buff ledges of magnesian limestone, partly concealed.

115. Red earth with chert.

113. Top of bench of rugged ledges of sub-crystalline magnesian limestone, (4th bench.)

110. Top of three foot bench of rugged weathering magnesian limestone, (3d bench.)

105. Bottom of second bench of buff magnesian limestone with segregations of calcareous spar.

100. Bottom of first bench of magnesian limestone of a reddish-buff color five feet thick.

100. Top of greenish-grey soft argillaceous shale and junction with first bench of magnesian limestone.

95. Continuation of same shales.
75. Bluish-grey shale, five to six feet thick.
65. Ash colored indurated marly clay, passing locally into a kind of hydraulic rock.
60. Heavy ledge buff magnesian limestone bedded one foot to six inches.
50. Rugged weathering beds of magnesian limestone.
Four-foot ledge of buff magnesian limestone.
39. Heavy ledge of same.
35. Same, soft and crumbling.
30. Same, soft and crumbling.
29. Base of this buff magnesian limestone, resting on ash colored argillaceous shale.
25. Junction of strata of Upper and Lower Silurian date.
20. *A. capax* and *Leptæna* limestones belonging to the Lower Silurian Period.
13. Alternations of buff and ash colored argillaceous calcareous rocks containing *Favistella stellata* and other Lower Silurian fossils—thin bedded.
0. Level of Withrow's run.

Bardstown is founded upon the Calymene beds of the buff magnesian limestone of Upper Silurian date. These magnesian limestones have been used in the construction of the court-house in Bardstown.

The highest beds in the previous section, (below all these benches of magnesian limestone,) that are referable to the Lower Silurian Period, contain, besides *Atrypa capax, Leptæna planumbona? Streptalasma, corniculma, Orthis lynx, (small variety,) Leptæna tenuiliniata, Pleurotomaria (subconica?) Orthis testudinaria,* and *Favistella stellata.* This latter fossil is generally the highest fossil in the series, before ascending on to the magnesian limestone and underlying shale; here it seemed to be in place some five feet below the above shells. This may be only an apparent exception to the general rule, since, from the softness of the intervening shaly clay, they wash away very fast, and the conseqence is the fossils roll down out of their original positions; this may have been the case in this instance, though they had very much the appearance of being in place a few feet under the fossil shells. Future investigations can determine the precise order of superposition.

Descending the next hill to the southwest of Withrow's run, a bed of apparently good hydraulic limestone comes in under the lowest bench of magnesian limestone, one foot to eighteen inches in thickness.

It is about two and a half to three miles northwest of Bardstown, where the peculiar mulatto soil, indicative of its derivation from rocks of the Upper Silurian Period, first marks the passage from the blue limestone formation to the overlying magnesian limestones, and has the same appearance as the soil over the equivalent formation in Boyle county, in the vicinity of Danville, where characteristic samples were collected for chemical analysis, which will give an approximation to the composition of the poplar land of Nelson, around Bardstown. Associated with the poplar timber in this part of Nelson are beech, white oak, red hickory, and sugar-tree. The magnesian limestones are, however, in much greater force in Nelson county than in Boyle; hence there is a greater area of this description of land in the former county.

On Witherow's creek, southwest of Bardstown, the buff magnesian limestone of Upper Silurian date, with their shale and clay partings, are a little upwards of one hundred feet thick.

The general opinion of the farmers of Nelson county seems to be that the land in the neighborhood of Fairfield is the best wheat soil of Nelson county. This part of the county I have not yet had an opportunity of examining.

The magnesian limestones of the upper part of the section, on Withrow's creek, prevail southwest of Bardstown to the vicinity of Cedar creek meeting-house. This is the locality where soil No. 719, of the Chemical Report, was collected, which is derived from the magnesian limestone, characterized by *Calymene Blumenbachii*, of Upper Silurian date. It is of a very different nature from the other Nelson county soils previously mentioned, as will be seen by consulting that report. There the growth is beech, large poplar, large white and black oak, hickory, and large black walnut. Below the level of the meeting-house is an excellent quarry of the buff Calymene magnesian limestone, five miles southwest of Bardstown. Here the soil is of a lighter color than the real mulatto soil around Bardstown. The paler color of the soil indicates less iron, though the sub-soil, where seen, seemed to be quite ferruginous. Small cedars spring up here over the old fields, and on the slopes of the hills.

The Calymene rock is overlaid by an encrinital and hydraulic limestone, probably of Devonian date. The hydraulic limestone occupies a higher geological position than the hydraulic rock, under the so-call-

ed "Comb Rock," a name given, in Nelson county, to the overhanging bench of magnesian limestone.

It is the middle beds of the magnesian limestone that weather most rugged, and possess the coarse texture and glistening granular structure so prevalent amongst the upper magnesian limestones of Iowa and Wisconsin.

In the western part of this county the Black and Ash-colored Devonian shale, and knob formation, are superimposed on the above encrinital and hydraulic limestones. Here the ash-colored shale includes beds of good workable iron ore, as in Bullitt county.

At Mr. Miller's, on the Rolling fork, several beds of buff and grey magnesian limestones are exposed above the bed of this stream. These beds are also well exposed at the forks of the Elizabethtown, Boston and Bardstown road, and at Troutman's distillery. At both places they have been quarried for building purposes.

In the Salt Spring Hollow, the overlying Black Devonian shale is exposed thirty to thirty-five feet; and at a level of twenty-eight feet above the top of this black slate, imbedded in the superimposed ash-colored shale, lies the knob, kidney, and block ore of Nelson county in place. This ore lies, for the most part, in the manner of a pavement, varying from twelve to sixteen inches in thickness. It appears to be pretty universally disseminated in a corresponding geological horizon throughout in the lower benches of the knobby region of this part of Nelson county; the principal difficulty experienced in mining the bed, is to find it in a situation where it can be reached without too heavy stripping, which can only be effected where there is a convenient off-set or bench. However, where the bed is of sufficient thickness to justify the operation, it can be mined by drift into the main hill side. At present, however, it has been found sufficiently convenient to enable the ore-digger to mine the ore at one dollar and a quarter per ton, at the bank, and to deliver it at the Nelson Furnace at two and a quarter dollars per ton; but there are considerable bodies of ore within a few hundred yards of the furnace that can be delivered even as low as seventy-five cents per ton.

At some of the ore banks, just under the knob freestone, at a higher level than the principal ore bed, a band of "sheet ore" has been found, not of as good quality, however, as the blue kidney ore, but still an ore which can be worked advantageously in connection with the

kidney ore. The Nelson Furnace had only recently gone into operation when I was in this part of Nelson county, in August of 1856. It is at present a cold blast furnace, calculated to produce from five to six tons in twenty-four hours. The limestone used as a flux is obtained between the Beech Fork of Salt river and the furnace. It is a greyish buff rock, and looks as if it contained a considerable proportion of magnesia along with the lime. None of the pig iron which had been produced during 1856 had yet reached the markets, but, judging both from the external appearance of the ore, and the samples of pig iron on hand at the time I was there, it will no doubt take a high rank in the market for softness and toughness. The hearth-stones at present in use are obtained from Hart county. The chemical analyses of the ores of Nelson, the limestone used as a flux, and of the slag and pig iron, will be seen by consulting the Chemical Report, Nos. 710, 711, 712, and 713. The kidney ore yields, as will be seen, thirty-five per cent. of iron.

From the surface indications there is every probability that the knob ore, will be found continuous from the southeast part of Bullitt county, throughout the knob formation of the western prolongation of Nelson county, perhaps even into Larue county, of workable thickness, and good quality, at a level of from twenty to fifty feet above the black slate.

The prevailing growth in the iron region is beech, intermixed with oak, hickory, poplar, walnut, and some cedars.

The following section was obtained near the Rolling fork meeting-House:

116. Top of knob back of the Meeting House; there were loose masses of chert on the surface.
78. Top of black slate, forty-two feet thick.
55. Site of camp on the 9th of August, 1856.
36. Base of black slate seen in branch.
12. Top of ledge of magnesian limestone.
10. Rugged weathering magnesian limestone.
Bluish-grey magnesian limestone quarried for abutments of bridge.
0. Low water of Rolling fork.

In the cut of the railroad at New Haven, five feet of buff Calymene magnesian limestone, with nests of calcareous spar, underlaid by other beds of magnesian limestone, are exposed twelve to fifteen feet.

Between our camp, at James Bell's, one and a half miles from New Haven, and for eleven to twelve miles along the Lebanon road, the Black Devonian Slate was usually found on the hills, underlaid, in the descents into the hollows, by the magnesian limestones, the principal thickness of which must probably be referred to the Upper Silurian Period. However, on account of the scarcity of fossils, and the great similarity in composition of the strata lying between the base of the black slate and the blue limestone, in this and the adjoining counties of this part of Kentucky, it is often difficult to decide upon the true age of the members underlying the black slate; this much, however, appears certain, that the calcareous rocks of Devonian date are much thinner in the southern part of Kentucky than immediately on the Ohio river, and cannot be represented but by a few feet of rock of this character, *below* the black slate.

The cuts of the New Haven and Lebanon railroad are generally made through the black slate, which has been used almost universally as the "ballast" on the road, not only in Nelson and Bullitt counties, but also some distance into Marion, and a considerable part of Jefferson county.

At a section, not far from the Marion line, a bed of hydraulic limestone lies between two marly argillaceous shales, beneath the rugged ledges of magnesian limestone. The same bed was seen at several other localities.

One to two miles west of the Marion line the *Favosites basaltica* occurs in abundance, indicating the junction of rocks of Lower Silurian date, which, as will be recorded under the head of Marion county, fairly emerged to the surface seven or eight miles from Lebanon, on the same road. In the southern extremity of the county, the above mentioned hydraulic limestone occurs apparently of excellent quality; also on Prather's creek, which empties into the Rolling Fork just below Raywick.

On Sulphur Lick creek sections of the black slate are exposed, from which issues a fine mineral water, known as the Washington Bell Sulphur Spring, but now owned by Ex-Governor Wickliffe.

About two miles north of New Haven, at the "Big Lick," there is a fine section exposed of the ash-colored shales and clay over the Black Devonian shale, containing considerable quantities of dissemi-

nated carbonate of iron, as represented in the following section, obtained at the locality, on the south slope of a bare hill side:

83. Band of carbonate of iron.
Ash colored shale.
76. Band of carbonate of iron.
Ash colored shale.
72. Band of carbonate of iron.
Ash colored shale.
70. Band of carbonate of iron.
Ash colored shale.
65. Bed of carbonate of iron, six to eight inches thick.
Ash colored shale.
60. Good band of carbonate of iron.
Ash colored shale.
36 to 37. Interrupted segregations of carbonate of iron.
Ash colored shale.
25. Segregations of carbonate of iron,
0. Near the black slate?

On the north side the following alternations appear:

85. Thin band of carbonate of iron.
Ash colored shale.
78. Bed of carbonate of iron, six to seven inches thick.
Ash colored shale.
71. Bed eight to ten inches thick of carbonate of iron.
Ash colored shale.
66. Bed, five or six inches thick, of carbonate of iron.
Ash colored shale.
67. Segregations of carbonate of iron.
Ash colored shale.
55. Bed of carbonate of iron, six to eight inches thick.
Ash colored shale.
51. Bed of carbonate of iron, six to eight inches thick.
Ash colored shale.
37. Principal bed of carbonate of iron, eight to nine inches thick.
Ash colored shale.
12. Heavy masses of carbonate of iron.
0. Black Devonian shale.

These beds and bands of carbonate of iron are often more or less interrupted, lying in a detached pavement form, the masses weighing, sometimes, twenty, forty, or even sixty pounds.

A section of about twenty to thirty feet of these same ash colored shales is exposed, in the cut of the Bardstown and New Haven turnpike, including two bands of ore about six inches thick.

The above ash colored or light-greenish-grey shale, exposed in the cut of the railroad, contains a large per centage of protoxide of iron, and but a small per centage of lime, according to a partial qualitative chemical test made of it, and therefore would hardly rank as a marl applicable for a mineral manure, at least not until after long exposure to oxidation, when it would doubtless be serviceable to sandy and siliceous soils from the clay, alkali, and peroxide of iron, which it would contain after thorough oxidation. Since the above was written Dr. Peter has completed the quantitative analysis of this shale, which shows that it contains but about 0.4 of a per cent. of carbonate of lime—see his report, No. 726.

There is also some good carbonate of iron, four to six inches thick, in the ash colored shale, two miles from the Sulphur spring, in the southern part of the county.

MARION COUNTY.

The surface of this county is very much diversified, and the most abrupt changes of soil occur in consequence of the frequent overlapping of different geological formations, even on the same hill side; this is the case particularly about Bradfordsville, the vicinity of New Market, and Raywick. As an example, I may cite a section taken adjacent to the Rolling fork of Salt river, near Bradfordsville:

100. Top of the bank.
98. Hydraulic looking fragmentary limestone, and some fragments of encrinital limestone, belonging, probably, to the sub-carboniferous group.
Cherty gravel.
Black lingula shale.
84. Do.
Hydraulic rock?
80. Encrinital, cherty sub-crystalline light-grey limestone.
75. Favosite and cystiphyllum bed; easily decomposing.
70. Thin bedded, marly and ferruginous layers.
65. Do., more silicious.
50. Thin bedded marly layers of limestone.
35. Two thicker bands, nine to eighteen inches.
Thin bedded marly limestones.
20. Do., with remarkable concretions.
Rough surfaced layer.
18. Concretionary thin bedded marly limestone, easily decomposing.
15. Do.
10. Greenish-grey hydraulic-looking layers containing O. lynx.
0. Bed of Rolling fork of Salt river at Bradfordsville.

All the layers up to fifty feet are probably referable to the Lower Silurian Period, but the fossils are so few and imperfect, except on the lower layers, that it becomes difficult to draw the line of junction.

The soil around Bradfordsville is considered some of the best soil in the county, no doubt from the fact of the materials of the argillaceous beds of the blue limestone contributing largely to the composition of the soil.

Though the encrinital bed, at eighty feet, is a light colored rock, it produces, by decomposition, a brownish-red ferruginous earth, very different in *color* from the derivative rock. This earth also contains disseminated *Cystiphyllum* and *Favosites*, such as occur in the Devonian rock of the Falls of the Ohio.

Eight feet below the bottom of the encrinital bed, the strata, though schistose in their character, have yet much the bluish-grey aspect and banded appearance of the magnesio-hydraulic limestones at the base of the group belonging to the Upper Silurian Period of Oldham county. But the thin bedded earthy green layers, about six or eight feet below, are, probably, of Lower Silurian date. The base of the section is, however, unequivocally of that period, as the *O. lynx* can be traced ten feet up from its base.

The thin bedded marly beds, at the foot of the section, might afford a good mineral manure for improving the adjacent silicious soils, especially the beds between ten and fifteen feet. At ten feet the rock weathers like a hydraulic limestone.

Lebanon stands on the verge of the blue limestone formation, the upper beds of which are exposed in the hollows.

The sets of soils collected three miles west of Lebanon, on Daniel Everhart's farm, have now been analyzed, and will be found recorded in the Chemical Report, Nos. 673, 674, and 675. This is one of the few instances in which the soil of the cultivated field has shown a larger amount of some of the incombustible elements of fertility, viz: the phosphoric acid and alkalies, than the virgin soil, and this anomaly is no doubt to be explained from the sudden and abrupt changes which occur in this immediate neighborhood, from one formation to another, where rocks of Upper Silurian and Devonian date are so thin and partial in their superficial exposure that often a few yards only intervene between rocks of different age and composition.

The red or mulatto sub-soil, No. 675, is richer in oxide of iron, lime, magnesia, and potash, than the surface soil, which indicates the benefits that may be anticipated from sub-soiling, when the land begins to show evidence of exhaustion. The nearest rock visible under the above soil, is an encrinital bed of limestone, that almost immediately underlies the black slate. This soil represents that of about one quarter of Marion county, particularly that west and east of Lebanon. The most abrupt transition from this soil to the stiff clay lands takes place near the southern edge of Daniel Everhart's farm, where it skirts upon the northern edge of the prolongation of the range of knobs that run south of Lebanon. It is in this range of knobs, where the Sulphur spring occurs, of which a proximate qualitative analysis is given in the chapter on mineral waters.

The stratification, four or five miles northwest of Bradfordsville, in the knobs between Pope's and Caney creeks, is—

Ash colored shale with carbonate of iron disseminated;

Black Lingula slate, fifty-five feet;

Hydraulic? limestone, two and a half to three feet;

Encrinital limestone, three to five feet;

Bluish-grey argillaceous shale, three to four feet;

Hydraulic limestone, three to four feet.

In the western part of the county magnesian limestones of considerable thickness come in over the lower hydraulic limestone, that are hardly recognizable southwest of and northeast of Lebanon, being, apparently, replaced in those portions of the county by marly shales.

All that part of the county bordering on Taylor county, is a knobby region, in which the ash colored shale and knob freestones are the prevailing rocks, with frequently black slate exposed at the base.

The cut of the Rolling fork, at Raywick, has exposed the upper members of the blue limestone.

SPENCER COUNTY.

The junction of the rocks of Upper and Lower Silurian date is near the line between Bullitt and this county. The beds of the blue limestone, at the junction, contain *Favosites* (*maxima?*) of Troost. *Ormoceras tenuifilium*, and *Leptæna alternata*, *L. sericea*, *O. lynx*, *A. capax*, *Streptolasma corniculum*.

Interstratified between the blue fossiliferous and magnesian limestones are some argillaceous marly shales, which might be applicable, as a mineral manure, to the adjacent exhausted magnesian limestone soils.

The predominating growth, where the blue limestone first emerges, in Spencer county, is beech, mixed with sugar tree, ash, walnut, and hickory. A sample of this beech land was selected for chemical analsis, between the waters of Beech and Bashear's creek, and is an average of the upland beeech soil of this county. The result of the chemical analyses will be seen by reference to Dr. Peter's report, Nos. 758, 759, and 760.

The nearest underlying rocks seen exposed are thin beds of Chætetes limestone, some beds sub-crystalline, and others close-textured, which, with Leptæna limestones, are the prevailing strata, in a northeast direction, to the Shelby line.

Northwest of Taylorsville, on Mr. Withrow's farm, the blue limestone affords some good building stone. No good sections have been yet obtained in this county, showing more than the superficial beds of the blue limestone underlying the soil, in the immediate vicinity of the Mt. Washington, Taylorsville, and Southville roads.

SHELBY COUNTY.

All of this county, so far as has been examined, is based on the blue limestones of Lower Silurian date. In the western part of the county, near Simpsonville, the growth is beech, hickory, oak, walnut, and sugar-tree, and the soil very much of the same character as that selected for analysis east of Taylorsville, in Spencer county. The specimens of blue limestone soil collected in this county, on Bullskin, from a farm belonging to the estate of William Crabster, on the waters of Bullskin creek, will be found reported in the chemical section, Nos. 755, 756, and 757. The growth, in this vicinity, is beech, large poplar, and shell bark hickory. The soil from the old field—No. 756—could not be collected from exactly the same geological level; the strata here are thin bedded and variable in their composition; these are, no doubt, the reasons why the soil No. 756 shows a larger proportion of carbonate of lime, oxide of manganese, and potash, than the virgin soil No. 755.

Another set of soils, Nos. 752, 753, and 754, of the Chemical Report, were taken from the southeast part of the county, from Addison Jesse's farm, over the Leptæna and Chætetes limestone. In this instance the sub-soil No. 754 is richer in potash, but not in phosphoric acid, than the surface soil.

On the east side of Little Bullskin the beds of blue limestone visible are chiefly the Chætetes beds. About half way up the slope, east of Big Bullskin, and five miles west of Shelbyville, the *lynx* beds are in place. The organic remains increase in quantity in the surface strata between this and Shelbyville, and a simultaneous improvement in the soil is visible. At Shelbyville the rocks are full of branching *Chætetes*, of both *C. lycoperdon* and *C. rugosus* forms, especially at a level of about ten to fifteen feet above the bridge over Bear creek, associated with *Orthis* and *Leptæna* beds.

HENRY COUNTY.

At Eminence, which is the summit level of the Louisville and Lexington railroad, there lies, close to the surface, or at least in a shallow cut of the railroad, a ferruginous clay, over and in which numerous bones and teeth of the Mammoth have been found, from time to time. They are, however, in such a soft decayed condition that it is difficult to remove them, and impossible to preserve them for any length of time, unless means are taken immediately on their removal to protect them from the action of the air, and fill the pores with some cementing material, as glue or varnish.

The soil is rather thin in the southern part of Henry county, though that portion around Eminence, resting on the ferruginous bone-clay, would certainly be very productive after sub-soiling.

The principal fossils in the rocks about New Castle are *Leptæna alternata, Orthis occidentalis, Glyptocrinus decadactylus.*

Drennon creek is about one hundred and seventy feet below Eminence, by the aneroid barometer, and the town of New Castle about one hundred and ten. The country between New Castle and Drennon Springs is rolling, the difference in the levels of the hollows and hills being from forty to seventy-five feet.

It is probably the prolongation of the vein containing sulphate of barytes and sulphurets of lead and zinc, mentioned under the head of Franklin and Woodford counties, runs near the Kentucky river, on the

borders of Henry and Owen counties, as some lead ore is reported to have been found between Marion and Springport.

The bluffs of the Kentucky river, on the eastern borders of the county, are three hundred and seventy-six feet above low water, where they were measured by the barometer.

OWEN COUNTY, CONTINUED.

On the opposite side of the Kentucky river, in this county, the height of the bluff was about three hundred and eighty-five feet, and the highest parts of the adjacent county four hundred and twenty-five feet. The highest beds underlying Mr. Jenkins' farm, where a soil was taken from the north-western part of the county for analysis, are shell beds of the blue limestone, containing *L. alternata* and *O. lynx*. The growth was chiefly beech, with small walnut. No silicious mudstone, giving character to the country, reaches the surface adjacent to the Marion and New Liberty road. The same kind of country prevails from New Liberty to Owenton. Six and a half miles south of Owenton some of the silicious mudstone makes its appearance, occasionally, on the surface.

About Twin creek the country is very broken, especially on the east side.

The buff silicious mudstone prevails mostly on the ridge between Cedar and Eagle creeks, amongst the beech timber. The hemp produced in this region of slicious mudstone, amongst the beech timber, does not "*lint*" well or produce good fibre; the quality is better where the oak and sugar tree flourish.

Near the heads of the Dick's fork of Caney creek the mudstone is seen, covered, locally, by coralline and shell beds of the blue limestone. At the Four Mile Tavern *O. testudinaria* occurs in the shell beds near the head of Indian creek. In the bed of this creek, about one hundred and fifty feet lower, the beds of the blue limestone contain *H.? bilex, A. modesta, Bellerophon bilobatus, Ambonychia* (*bellistriata?*) and one layer is charged with *Nucula* (*levata?*).

The soils collected four miles from Owenton—No. 738, 739, and 740—have been analyzed, and are reported in the chemical section.

Near the edge of Owen and Scott counties, a soil was collected for chemical analysis, about one hundred feet above the Nucula limestone, from the old Jemison farm. There is no silicious mudstone in this

vicinity worth mentioning, at least none imparting character to the above soil.

NICHOLAS COUNTY.

On the western edge of this county, on the slopes of Hinkston waters, the country is rather broken, but the soil of the upland, over the red under-clay, with gravel iron ore, must be productive under an efficient system of farming. The upper part of the formation, on the Hinkston hills, is an ash-grey earthy rock—a kind of marlite. These strata alternate with dark-grey-blue sericea and coralline beds of limestone; the whole resting, about two-thirds of the way down the slope, on an Orthoceras bed of limestone. The derivative soil, in dry weather, has the peculiar crisp grain indicative of a rich retentive calcareous clay, but is no doubt stiff and muddy in wet weather.

In some of the slopes near Carlisle the beds of silicious mudstone crop out, especially on the west and southwest slopes.

There is little or no beech timber up Hinkston; but this kind of lumber is abundant on the east side of the Maysville turnpike, and on Beaver creek, and east of the line adjoining Harrison county, near Headquarters.

The water that runs off from the slopes of the ridges, about seventy feet above the valleys, over the out-crop of the silicious mudstone, where this description of rock has been laid bare, by the washing of the hill sides, is highly charged with magnesia, much of which is probably in the state of chloride, as reagents indicate a large proportion of both ingredients. This water is also milky from suspended particles of either extremely fine silex or clay. There are many facts which go to show that this description of water acts injuriously both on man and stock, if habitually used, as I have explained more fully elsewhere in this report.

In the northeast part of the county, the pale or light yellow silicious soil, similar to that in the adjacent part of Bracken, is good tobacco land. The "black soil" of Nicholas county lies mostly in the southern, and some portions of the western districts. The mulatto soil is most prevalent in the western part of the county. The best agricultural region lies southwest of a line running from near Headquarters, by Forest Retreat, to Moorfield.

Sets of soils were collected for chemical analysis in this county, from Jonathan M. Tanner's farm, on Stoney creek, where the original growth was white and red oak, poplar, black ash, and beech; the undergrowth red bud and spice wood. These have not yet receeived a chemical examination. The limestone lies so near the surface here that it is difficult to sub-soil except in the flats. The substratum of limestone, of easy decomposition, seems, however, to supply new fertilizers to replace the removed ingredients. The hill sides are a good deal disposed to wash, but this may be avoided by care, as the blue-grass has a great disposition to spread over this land, which, if allowed to take root, in time effectually prevents the washing of the soil.

The sterity of the soil on the Cedar Hill, on the site of the celebrated battle ground, near the Lower Blue Lick Springs, on the opposite side from the Lick Springs, has often been a matter of wonder, inasmuch as the principal mass of the hills is composed of the beds of the same blue limestone formation which affords elsewhere so fertile a soil. The explanation of this remarkable phenomenon is found in the fact, that at an elevation of about one hundred and thirty to one hundred and forty feet above low water of the Licking river, the fossiliferous beds of the blue limestone are here covered up by barren sand, and quartz pebbles, strewed over the site of the battle ground. This sand and gravel lies from seventy to eighty feet above the layers of the blue limestone, exposed not far above the bridge, which contain *Calymene senaria, H? bilex, A. gigas*, and branching *Chœtetes lycoperdon*. This is an unusual occurrence in this geological position, having been only previously seen, during the geological survey in Kentucky, in Pendleton county, as stated on page 109 of the first part of this report.

It has been a question whether this may not be the debris of a sandstone conglomerate, occupying the same geological position as the Oneda conglomerate of New York and Pennsylvania. Its position on the battle ground, near the banks of the Licking, seems to be rather too low for the horizon of the Oneida conglomerate, as placed in the New York system, since we find *O. testudinaria, Constellaria, (Stellipora,) Autheloidea, O. occidentalis*, and *L. planumbona*, and other fossils, both of the Trenton limestone and Hudson river group. Nearly the whole of this material is in the form of loose sand and gravel, but it has all the appearance of having been derived from an incoherent conglomerate

rock, which once occupied the place of this stratum of coarse sand and gravel, so different from the sedimentary calcareous and argillo-calcaleous beds above or below it, as it is also very different from the materials of the fine textured silicious mudstones, which lie nearly two hundred feet high above the battle ground. At all events there is conclusive evidence here of a coarse and pebbly material, swept in by local currents, in the midst of strata of the blue limestone formation of Kentucky, and, to all appearance, belonging to the age of the Lower Silurian Period. At least it is too extensive, too high above the bed of Licking, and too far removed from any of the more recent conglomerates known to exist, in place, in the valley of the Licking, to admit of its origin being explained in a satisfactory manner, by transportation from a distance during modern periods.

MASON COUNTY.

The junction between the rocks of Lower and Upper Silurian date is very near the eastern line of this county, where it joins Lewis, on the waters of Cabin creek, so that nearly the whole area of the county lies within the limits of the blue limestone formation. The highest beds of this formation, on Cabin creek, lie about one hundred and forty to one hundred and fifty feet below the level of the "Poplar Ridge" of Lewis county.

The river bluffs, back of Maysville, are composed entirely of blue limestone clay, and marlite, belonging to the Lower Silurian Period. At one hundred and fifty to one hundred and sixty feet above the Ohio, there are alternations of thin bedded limestone and marlite. At one hundred and eighty-five the *O. testudinaria* and *Leptæna* beds are in place, with alternations of the lower silicious mudstones, and eighty to one hundred feet higher the *O. lynx* beds commence, and can be traced near the summit level, which is about four hundred feet above the bed of the Ohio river. The highest beds are argillaceous limestones, containing the above fossil, of a dark-bluish-grey color, which turn brownish-grey by exposure, and the derivative soil has much the same color; this is due to the peroxidation of the iron, which exists in the deep-seated rocks as protoxide.

Mason county has long been celebrated for the fine quality of tobacco which it produces. It is generally admitted that the western portion of the county, adjoining Bracken, possesses the best tobacco

land, especially in the vicinity of Dover, and on the Tuckahoe ridge. This soil produces that quality of fine silky tobacco used almost exclusively for wrappers. In the vicinity of Dover the hill-sides are generally selected where the middle beds of the blue limestone prevail, characterized chiefly by *L. sericea*, associated with lower beds of silicious mudstone, some layers of which are charged with *Chonetes?* These hill-sides are generally abrupt, and differ but little in their geological appearance from the hills within the range of the blue limestone formation, where the equivalent members of this formation crop out. A genuine virgin tobacco soil was collected in the vicinity of Dover, from Mr. Arthur Fox's farm, about one hundred and fifty feet above the river, together with an exhausted tobacco soil, which, though good at first, has, by cultivation, lost some essential ingredients to the production of the best tobacco.

The soil of the Tuckahoe Ridge must be of a somewhat different character, as it overlies the lynx beds of the blue limestone, which are some two hundred feet or more higher in the formation than the sericea limestones and lower mudstones. Time has not yet permitted the analysis of these tobacco soils.

At Lawrence creek, where the Dover road leaves the Maysville turnpike, there are ledges of thin-bedded blue limestone and soft marly clays and marlites, like those noted in the river hills about one hundred and sixty feet above the Ohio river; and a short distance below the toll-gate, on the Dover turnpike, the lynx and occidentalis beds are in place, about thirty feet below the summit levels of this part of the county. These same beds of a dark bluish-grey color, are seen in a quarry on the north side of the road, opposite the school house, where they have been quarried for metalling the turnpike. This is thirty to fifty feet below the general level of the Tuckahoe Ridge. From the appearance of the crops of wheat on this ridge, in August of 1857, it must be excellent wheat land.

A little above high water, in the vicinity of Dover, there is a great quantity of gravel drift, which no doubt imparts peculiar qualities to the bottom land; but this does not seem to be the soil preferred for tobacco, which is the hill-side soil, fifty to one hundred feet above high water, where the sericea limestones alternate with the chonetes?—silicious mudstones.

The best tobacco land in the vicinity of Germantown is the oak-land, in the so-called Texas District, a few miles south of this town.

The country on the borders of Bracken and Mason lies well for farming, being more level than the northern parts of these counties.

At the point where the viaduct of the Lexington and Maysville railroad crosses the north fork, of the Licking, near Lewisburg, the lynx beds are seventy-five feet above the bed of that stream, and twenty-five feet above the level of the railroad track. The limestone here is bluish-grey in color, and argillaceous, prone to decomposition, and some of the more earthy associated layers have imperfect impressions of what seems to be plants, probably some portions of *fucoides*. The orthis beds here are more solid and less earthy than the other layers, but all are liable to disintegration, and make but inferior wall rock.

The lower beds are not so fossiliferous as the upper; those that do occur seem to be of the same species, viz: *O. lynx*, *L. alternata*, a large *Bellerophon*, and a warted form of *Chætetee rugosa*.

Near the edge of Mason and Bracken, on the divide between Lee's and Bracken creek, the lynx beds just skim the tops of the ridges, associated with concretionary beds of limestone. The overlying soil supports a growth of sugar-tree, mockernut, hickory, large black walnut, honey-locust, and mulberry. This formation prevails with the accompanying soil and timber all around Washington. To the west of this place the oak-lands are soon reached, indicative of the alternations of testudinary beds and silicious mudstones, affording the best tobacco soil on the table lands of Mason, some of which have a reddish yellow or mulatto color. The oak timber is interstratified with sugar-tree, hickory, walnut, honey-locust, and some beech. Hemp, corn, and wheat are the chief products around Washington. There are, also, extensive stock farms.

BRACKEN COUNTY.

The eastern part of this county is very much of the same character as the western part of Mason county, and possesses a soil equally well adapted for the growth of the fine kinds of tobacco, for which purpose the hillsides, about the same level above the Ohio river, are generally selected. Several young vineyards have been planted out on the steep slopes of the hills near Augusta, having a south and southeast aspect; and the citizens of this part of the county entertain high hopes of

the successful and profitable cultivation of the vine in their county. If this new branch of industry proves successful, there is no doubt but this is the very best purpose to which such lands can be applied; and this remark holds good for many districts of adjacent counties, situated on the blue limestone formation, where the hill-sides are abrupt and liable to wash from constant cultivation in grain.

A hill-side soil was selected for chemical analysis, in the vicinity of Augusta, such as is there most generally considered best for grape culture, over the testudinaria, Leptæna, and encrinital beds of the blue limestone formation of this county. When these analyses shall have been completed we shall be better prepared to pronounce on the adaptability of this soil for vine culture; but, judging from the character of the underlying rocks, there is every reason to believe that they will prove to be soils, not only rich in carbonate of lime, but, at the same time, sufficiently silicious to be warm, porous, and genial to the grape.

I believe all experience goes to show that the best *"dry wines,"* such as are produced in the south of France, and the Xeres, Malaga, San Lucar Districts, of Spain, are warm, porous, calcareous soils, easily permeable to water, but still somewhat retentive, by its composition, and located with a good southern exposure on hill-sides, towards the middle of their slopes. Such is precisely the kind of soil which may be expected to result from the disintegration of alternations of the blue argillaceous limestone and silicious mudstones, not only of Bracken and Mason, but over a large portion of Nicholas, Pendleton, Harrison, Scott, Owen, Grant, Carrol, Gallatin, Boone, and Kenton. If the climate of Kentucky is not too variable the hill-sides in these counties, through which the rocks in question range, can undoubtedly be more profitably cultivated in vineyards than in any other way. By so doing, it is anticipated that the owner of the land will not only realize, ultimately, a fair return for his labor, but he will, undoubtedly, at the same time, beautify the face of the country, and prevent the the disastrous consequences which often follow the continued cultivation of land thus situated, in grain, by the washing away of the soil, and often the furrowing of the surface into unsightly bare gullies, that mar the prospect, and deteriorate the value of the property.

"The highly esteemed wines of the Cote d' Or are produced from "vines grown on a calcareous soil; but the land which produces the "Hermitage wine is derived from the debris of granite; silicious soils,

"interspersed with flints, furnish the celebrated wines of Chateau-"Neuf, Ferte, and La Gaude; schistose districts afford also good wine, "for instance, that called *La Malgue*." Thus it appears that soils, various in their chemical composition, produce wine; but each has its peculiar flavor and character, depending on the nature of the soil on which it is grown.

Wine is now coming into more general use in this country, every successive year, as a substitute for brandy, whiskey, and other strong intoxicating liquors; and there is no doubt that genuine good wine, used in moderation, is a wholesome beverage, at least for some constitutions. If by its introduction, the cause of temperance can, perhaps, be more effectually and permanently established, which is now the opinion of our most enlightened and intelligent citizens, vine growing would indeed be a blessing to the land, as well as a new source of industry and profit. Such being the case, the demand for native wines is now becoming established, and the products of the vineyard have a sure market, which is the principal step towards its successful cultivation.

In France the average price of vineyards has been estimated at two hundred dollars per acre; even at this price, and taking into account the frequent failure of the crop, it is still one of the most important and profitable branches of industry. It has been remarked, by those well acquainted with the wine growing districts of France, that though it requires four or five years after a vineyard is first planted, before it comes to perfection, and, though this branch of husbandry is liable to frequent vicissitudes from occasional unproductive seasons, that, nevertheless, there is scarcely any agricultural product that pays so well in the end.

The town of Xeres, in the southwestern part of Spain, is said to be one of the richest cities in that country, its commerce being chiefly derived from the fine quality of Sherry wine produced in the vicinity.

It is asserted by Mr. Nicholas Longworth, who has probably had more experience in native wines than any man in our country, that *must* obtained from the kind of grape that flourishes best in Ohio soil and climate, has a higher specific gravity than the *must* of the majority of European grapes. I am not informed as to what he has found to be the average specific gravity of the *must* of the western grapes, tried by him; but those who have an opportunity of ascertaining may com-

pare it with the following specific gravities of the *must* of grapes grown in different parts of Europe. In the south of France it will average 1.1283; in the district of the Neekar, Germany, from 1.050 to 1.090; in Heidelberg from 1.039 to 1.09.

Some trials were made this season of the specific gravity of the expressed juice of grapes, after straining through thin muslin, with the following results:

First specimen of Catawba, 1.0604; second specimen of Catawba, 1.0703, to 1,07027; one sample of Warren or Herbemont, 1.070; one specimen of Isabella, 1.050. This season, which has been a wet one, the juice of the grape is probably more watery than in the average of years, so that the average specific gravity would probably rise higher than the above figures. These grapes were grown in silicious loamy Wabash bottom soils, about a quarter of a mile from the base of a range of hills composed of silicious quarternary shell marl.

The aspect seems to be a very important consideration in laying off vineyards, as well as a judicious selection of soil.

In the celebrated wine districts of Montrachet, experience has shown that the middle part ef the slope, with a southern exposure, produced by far the best flavored wine; the insulated parts towards the tops of the hills afford a wine which is less esteemed, and sells at a much lower price, while beneath, on the lower slopes, and in the surrounding plains, the vines afford still an inferior article of wine, and yet more indifferent on the opposite side of the hill. Similar differences are observed in the wine countries of Pomard, Volnay, Beaune, Nuits, Vougeot, Chambertin, Romanee, &c. Almost everywhere it is observed that the reverse side of the hill, the summit and the plain, although apparently consisting of the same soil, afford inferior wine to the southern middle slope. It appears requisite that the vine, to flourish, must be able to push its roots into a warm dry place; and it seems to be advantageous, too, that it should be able to insinuate them amongst the interstices of a calcareous rock bottom.

The question, then, of the suitability of the climate of Kentucky becomes a matter of very great interest. From hints thrown out recently, by some of the Cincinnati papers, in regard to the present opinion of the Cincinnati Horticultural Society, they consider the seasons in Ohio as too variable—one winter too cold, the next too open

and warm; one summer is too dry and too hot, another too wet. It must be confessed that the last three years have been unfavorable for vine culture, and if we were to judge from these least three years we might come to the same conclusion; but opinions, based on the experience of previous years, are rather at variance with this view of the question; we ought, however, not to allow ourselves to be deceived in regard to this important question with reference to the raising of grapes; therefore, all those about to engage in the business would do well to investigate this subject for themselves, by informing themselves, personally, in regard to this matter, by visiting the oldest vineyards in the country, and ascertaining the facts of the case.

It is asserted that the oldest vineyards in the country, around Vevay, in Indiana, have been abandoned, and that more money can be made from land by raising grass, wheat, and corn, than by cultivating grapes. This may be all true, under certain conditions, but it may still be an open question under other circumstances. Since, in the first place, we have to consider whether the Vevaians selected the kind of grape best suited to our climate; and we have also to consider the peculiar nature of the soil they selected, which I understand to have been bottom land. Steep hill-sides have been thought best adapted for grape culture in Kentucky. The question is can *such lands* be as profitably, or more profitably, put in grain and grass? I have seen many such a hill-side, reduced almost to hopeless barrenness by the washing away of the soil, and the gullying out of the face of the slope. The hill sides, if well sodded in grass, would, undoubtedly, be valuable for growing wool, but at present, in consequence of the ravages of the multitude of dogs kept by the citizens, Kentucky is almost debarred the privilege of raising sheep.

The following reply to the discouraging reports of the Cincinnati Horticultural Society, on the vine culture of the United States, appears to me so just and so pertinent to the question at issue that I insert it here:

VINE CULTURE IN THE UNITED STATES.

To the Editor of The N. Y. Tribune:

SIR: I noticed under the above title, in *The Weekly Tribune* of September 5, an extract from *The News*, published in Vevay, Indiana, which I wish to answer, for coming from a section of country which is considered properly the Vine region of the United States, it gives an-

thority to an error which needs correction. The writer regards it as a settled fact that the cultivation of grapes cannot be rendered general in this country. I would like to be informed what product of the soil there is, the cultivation of which could be rendered general in a literal sense, particularly what fruit can be grown to advantage in all sections of the United States. Soil and climate adapted to one product may be unfit for another. The writer attempts to prove too much. The cultivation of the vine cannot be said to be general even in Southern Europe. I apprehend that there are portions of land wholly unadapted and never planted to vineyards, even in the most celebrated vine regions of France and Germany. Nor can I conceive that their climate is any better adapted to the grape than ours. True, the weather there is more uniform than here, so that they have not to contend with mildew and rot as we have; but their grapes are often destroyed by early Autumn frosts. They have grapes adapted to their climate; we have grapes adapted to ours. I admit that our climate is more variable than theirs, our weather fickle and austere, and even in the most favorable locality so different from theirs that we can never raise foreign grapes in the open air. But we have native grape vines that withstand the severity of our northern latitude, and yield an abundant crop every season. And I trust that scientific men will, in a few years, by a process of amelioration, produce from our crude native stock varieties unequaled by Muscat or Chasselas.

There may be, and doubtless is, land in the Ohio river valley worth more to raise grass and corn and wheat than to raise grapes. But I believe there are portions of land, not only on the banks of the "Rhine of America," but in every section of the United States, better adapted to vineyards than anything else. I am too sanguine to believe that it would result in ruin to any man who should enter into the culture of the vine with a rational understanding of the habits of our native grapes and the soil, climate and treatment adapted to them.

Doubtless Mr. Longworth and many others would be gratified to learn that process of adulteration in the manufacture of wine to make a little go a good way. This assertion will be news to those acquainted with the celebrity of this gentleman's wine. But the manufacture of wine does not comprise the only value of grapes. If I remember correctly, the minimum wholesale price of Isabella grapes in New York City last season was seven cents per pound. At times the price was doubtless twice that sum. Mr. E. A. McKay, a grape-grower in Naples, N. Y., sold his entire crop last season in Buffalo and Montreal at an average of fourteen cents per pound; and a few years since he realized $1,200 from the product of one acre. At these figures, to raise grapes for the table would be more profitable than making wine, even with that process of adulteration.

But what is the secret of failure to those who have attempted the culture of the vine in this country? Many have failed by attempting to cultivate foreign varieties, all of which are worthless for the open air in our climate; and when attention was directed to native grapes, those establishing vineyards would employ and rely upon the judgment of German vinedressers, who must do their work "choost as they did it in Charmany," forgetting that our native vines, unlike the foreign, put forth large, luxuriant leaves to protect the fruit from our more intense sun and those sudden changes so fatal to the foreign grape, and to mature a more hardy wood to endure our Winters. The Swiss at Vevay planted their vineyards on the rich bottom lands. The result was what any intelligent cultivator might expect, an enormous growth of wood and but little fruit. Those farmers have acted wisely to destroy such vineyards, and devote the land to other purposes. But the few vineyards left in that vicinity are of native grapes upon hill sides, and I believe are in a flourishing condition.

Respectfully, A.

EGYPT, N. Y., *September* 9, 1857.

In this connection I would also state an important fact bearing on this subject: that in the wine districts of the Neckar, a full crop of grapes is only obtained once in ten years, and yet wine growing pays in that part of Germany.

At all events the practicability in this country, of successful grape culture, is well worthy of the serious consideration of the land owners of the commonwealth.

There are three principal varieties of soil in Bracken county: the argillo-calcareous and silico-calcareous soils, of the middle slopes of the hill-sides, supporting a mixed growth of sugar-tree, walnut, hickory, interspersed with black and white ash, oak, buckeye, and wild cherry; the oak land proper of the ridges and table lands, and the bottom lands. The former prevail principally east of the Augusta and Powersville turnpike; the oak-land in the southwest part of the county, bordering along the Newport trace, where the large white oak flourishes, intermixed with red and black oak.

It is the sugar-tree, hickory, and sassafrass land that brings tobacco of the finest quality; but the black oak land is also excellent tobacco land. The tobacco grown on the best tobacco soils of Bracken and Mason is remarkable for the fine texture, glossy appearance, and freedom from the gummy principle which deteriorates the coarser qualities of this plant. After a few years cultivation the best tobacco soils lose

some of the properties necessary to produce the finest quality of silky tobacco, which it seems difficult to restore. Perhaps the chemical analysis of some of the exhausted tobacco soils may throw light on this matter. They will probably show, for one thing, a loss of soluble potash salts. A fresh disintegration of the soil and green crops seem, after a time, partially to restore the fine tobacco producing quality. A virgin tobacco soil was collected in this county for chemical analysis.

From four to five feet below the surface of the alluvial plain, on which Augusta stands, innumerable quantities of human bodies, of aboriginal races, are entombed. So abundant are they, that in digging a cellar under one of the houses from fifty to sixty skeletons were found. An exceedingly rich black shell earth is also frequently turned up in some of the gardens, by the spade and plough; they are river shells such as now exist in the Ohio river, viz: several different kinds of *Unio* and *Paludina*. From their position here, in a rich black earth, both in the Augusta bottom, and in the same material in a high situation in the cut-off hills of the Lower Wabash in Indiana, more than one hundred feet above the bottom lands, I am convinced that in seasons of scarcity these moluscs served as an article of diet, and this black shell earth is the site of aboriginal dung hills, where the shells were cast away after the repast on this singular food; that which lends probability to this inference is the fact of bones of deer, elk, opposums, racooons, and other animals occurring in the same black earth associated with the shells. The richness of the soil, the great elevation at which the same shell earth has been found in Indiana, as well as its local circumscribed area, forbids the idea of its being a river deposit.

The human bones are generally surrounded by a black clay or loam, and are mostly in so tender and decomposed a condition that it is difficult to exhume them entire.

Near the toll-gate, five miles from Augusta, on the Germantown road, the *O. testudinaria* beds are well developed, associated with silicious mudstone. Here the growth is beech and oak.

The Willow creek oak-lands, and most of the country lying between the Germantown turnpike and the Mason line, are good tobacco lands.

Near the head of Locust creek there is a considerable quantity of silicious mudstone, interstratified with testudinaria and Leptæna lime-

stone; here the growth is chiefly oak and hickory; this is part of the same ridge of oak-land, previously spoken of, which extends for a long distance through Pendleton county, following the strike of these members of the blue limestone formation, and is prolonged, eastwardly, to Washington, in Mason county, along the nearly continuous ridge, known as the Newport trace.

Some very singular impressions were noticed near the heads of Locust creek, in the mudstones, having much the appearance as if wires, terminated by small balls, had left their impress on the rocks.

A virgin tobacco soil was selected from Bracken county for chemical analysis, in the vicinity of Augusta, where the growth is sugar-tree, walnut, white oak, buckeye, elm, sassafrass, and hickory; undergrowth, sassafrass and ironwood. Time has not yet permitted the analysis of this soil.

Lewis, Fleming, Bath, Rowan, Montgomery, Estill, and Madison counties.

All these counties are exceedingly varied, both in their physical and geological character. The lower sub-carboniferous rocks range through a large part of their middle and eastern portion, coincident with the knob-shaped range of hills; resting, throughout their entire course, upon the black Lingula shale; while their eastern area is chiefly occupied by rocks of Silurian date, comprised both in the upper, or magnesian division, and lower argillo-calcareous division of that system.

The approximate boundary between the rocks of Lower and Upper Silurian date, as far as ascertained, up to the present date, ranges through these counties as follows:

Commencing near the Ohio river, one hundred and fifty feet down the eastern slope, below the level of the Poplar flats, near where Cabin creek leaves Lewis county in its course into Bracken, the boundary line runs near the confines of Lewis and Mason counties, into the northern corner of Fleming, passing one to two miles west of Mount Carmel; crossing the Poplar Plains turnpike, about two miles south of Flemingsburg; but the blue limestone continues to be seen in the hollows as far to the south as Poplar Plains; thence the line runs not far from the road leading from Poplar Plains to Hillsboro, crossing the Licking above Wyoming it enters Bath near the valley of Slate creek.

In Bath the boundary line can hardly be defined by a single line, since the yellow magnesian limestone, of the age of the Upper Silurian Period, occupies the high grounds around Owingsville, so that the boundary line embraces both sides of that high table land north and south of Owingsville, in Bath. The exact point where the continuation of said line enters Montgomery county has not been ascertained, but it is somewhere not far from Howard's mill; crossing thence, a few miles south of Mt. Sterling, to Kiddsville, on the confines of Clarke county; thence down the valley of Howard's upper creek to a point on the line between Clarke and Madison counties, not far from the corner of Clarke, Estill, and Madison counties; thence at first south, up the valley of Drowning creek, to near the crossing of the Irvine and Richmond turnpike; then, with a southwest bearing, it passes through Madison county, within about two miles south of Richmond. The belt of country occupied by the yellow magnesian limestones of Upper Silurian date is, for the most part, quite narrow, except in the region of the Poplar Flats, in Lewis county, and the Poplar Plains, in Fleming county—its average width being not more than two or three miles.

The rocks of Devonian date are so thin and obscurely marked, that at present they can only be defined as occupying a very narrow belt of country immediately northwest of the next line, about to be described.

The zone marking the Clinton group would be represented by a still narrower belt, and probably not universal, in the above counties, bordering southeast of the previously described line.

The approximate southeast boundary of this yellow magnesian limestone, marking its junction with the black slate which follows in the ascending order of the formations, is as follows:

Commencing on the Ohio river in Lewis county, between the mouth of Quick's and Salt Lick creeks, it runs up the valley of the latter stream within a few miles of the Esculapian springs; thence, by the heads of the north fork of the Licking, to a point on the line between Lewis and Fleming, a few miles southeast of Mount Carmel; thence southwest through Fleming, nearly coincident with the range of the knobs, to a point on the Licking, not far from the corner of Rowan, Fleming, and Bath; thence by the heads of Indian, Cow, and Slate creeks, in Bath; thence, meandering with the northwestern spurs

of the knobs, by a complicated line near the borders of Montgomery and Powell counties, which can only be defined by the detailed topographical survey, to a point in the southeast corner of Clarke county, between the oil spring and Kiddsville; thence, to a point on the line of Estill, not far above the mouth of Drowning creek; thence in a southerly course, through Estill, to a point on the Kentucky river, near the mouth of White Oak creek and the Covered Rock; thence to a point on the confines of Estill and Madison county, near the Dug hill, and where the Irvine and Edinburg road crosses Drowning creek; thence through Madison county, by a line not yet properly defined, running near the heads of Paint Lick and the Red Lick fork of Station Camp creek.

The belt of country occupied by the black slate is exceedingly irregular, its meanders conforming, in a great measure, to the base of the various spurs and outliers of the range of knobs, but rising, in certain places, even to near their summits, usually narrow in its superficial area, but expanding locally in parts of Lewis, Bath, Estill, and Madison, to a belt of eight or ten miles in width. The outcrop of this belt of black slate is so intimately connected with the complicated topography of the country that it can only be properly defined after the construction of accurate maps of each county through which it extends.

The greater portion of the region of country lying between the eastern confines of the black slate, and the line defining the Coal Measures, described in a previous chapter, is occupied by the fine grained freestone of the knobs, since, in these counties of Kentucky, the subcarboniferous limestone has no great thickness, and is generally only seen in a bench of the hill-sides, interposed between the top of the fine grained sandstone and the coarse sandstones and conglomerate at the base of the Coal Measures.

LEWIS COUNTY.

The eastern part of this county is occupied chiefly by the fine grained knob freestone, and associate grey and ash colored shales belonging to the lower subcarboniferous group. The black Lingula shale is, however, frequently seen towards the base of the knobs.

The lower sections of the Salt Lick valley expose the yellow magnesian limestone from below the Esculapian springs to Clarksburg,

which can be traced, in some places, from seventy to one hundred feet above the bed of Salt Lick creek, with black slate reposing almost immediately upon it, with the intervention of some reddish ferruginous shale.

Two to three miles above the mouth of Salt Lick the yellow magnesian limestone shows itself only near the bed of this stream, and a short distance above its mouth a good section of the black slate of nearly one hundred and forty feet is exposed. In its lower twenty-five to thirty feet are enclosed enormous Septarian segregations, three feet in diameter, portions of which are highly ferruginous, while others have the appearance of hydraulic limestone. Here the strata dip 1° to the south.

Under the black shale in the bed of Salt Lick creek, near its mouth, the yellow magnesian limestone is seen also in the bank of the Ohio river below Vanceburg, but only seen there in a low stage of the river. These beds are concretionary, and the upper layer quite cherty. Large blocks of this material are seen in rugged projections, where the action of the river has worn and carried away the softer matrix. Below this cherty mass is a grey calcareous bed, which may possibly be referable to the age of the Clinton group of the New York system; but the few imperfect brachiopeda found in it did not enable me to decide with confidence on its exact age.

The best section which I have yet obtained, of the fine grained freestones and shales, of the knobs of Lewis county, was in the river hills, at Rockport, seven or eight miles above Vanceburg; the zero point is high water mark, and about one foot below the grade of the Maysville and Big Sandy railroad.

354. Top of a low sag or gap of the knob.
349. Top of highest exposed ledge of brownish knob freestone.
345. Bed of brownish knob freestone one foot in the bedding.
322. Top of fine grained greyish buff beds of knob freestone.
320. Foot of do.
317. Ledges of similar rock six inches to one foot in the bedding.
298. Top of bold ledges six inches to one foot in the bedding.
296. Eighteen inch bed of do.
276. Fourteen inch bed of good quality.
270. Ledges of do. six inches to one foot.
Space with soft shale.
265. Top of ledges of freestone under shale.

260. Four foot bed of greyish buff freestone.
255. Foot of conspicuous bench of knob freestone six inches in the bedding.
Space concealed, shale in part.
137. Top of second bench of knob freestone seen above railroad grade.
133. Foot of do. about two feet in the bedding, but weathering on a slope.
Space concealed, with shale or soft argillaceous freestone.
125. Top of first bench of knob freestone one to one and a half feet in the bedding.
120. Bottom of do.
Space concealed, top ash-colored shale?
90. Top of second bench of talus of loose material fallen from above.
Concealing ash-colored shale?
45. Top of first bench of loose material washed from above.
0. High water of the Ohio river below Rockport, Lewis county.

The knobs bordering on the river are from five hundred and fifty to six hundred feet above low water of the Ohio river, and some of the highest may reach an elevation of seven hundred feet above the same point. These knobs contain some valuable freestones for building purposes; the principal difficulty experienced in obtaining them, is to find them exposed in situations where they can be reached without too much stripping.

Better sections of these freestones are exposed on the Ohio side of the river, where this rock has extensive quarries for building purposes, near Rockville. The quarries were examined and reported on by Dr. Locke many years since. According to his measurements, at the Rockville quarries, on the Ohio side of the river, the best building material is at an elevation of four hundred and sixty-five feet above low water mark of the Ohio river, at Cincinnati. This will be about four hundred and twenty-five feet above low water at Rockville.

In Loughery's quarry there is about twenty feet of freestone and shale cut through, of which seven feet is shale and thirteen freestone. Two of these layers are esteemed the best for building purposes—the "white ledge" and the "city ledge." The white stratum is, according to Dr. Locke, the most perfect and beautiful stone in the quarry, but not so much consumed as the "city layer," because it is harder to work. The "city ledge" has a stratum of fifteen feet of shale both above and below. The stratum of building stone itself is about 2.5 feet in thickness.

At one of the quarries at Rockville the layers of building stone are remarkable for their paralellism and uniformity of thickness, and from

the length and perpendicularity of the section which exhibits them; this is known as the "beautiful quarry," of which Dr. Locke gives the following section:

		Feet.
1st.	Building stone,	0.7
2d.	Building stone,	1.0
3d.	Eight layers, each 3 inches, separated by 1 inch of shale,	2.7
4th.	Shale,	1.20
5th.	Building stone,	1.35
6th.	Six layers, each about 3 inches, separated by 2 inches of shale,	2.7
7th.	Eight layers, each 1 foot,	8.0
9th.	Building stone,	1.5
		19.15

Out of these nineteen feet of material there are only 2.5 feet of shale; this is the reason why the beds are so very regular, as the undulation of the rock is about in proportion to the amount of shale and soft material interstratified.

The strata above this quarry are about one foot thick on an average, separated only by seams; in one instance three feet four inches.

These data, derived from measurements on the Ohio side of the river, may be of service in opening quarries on the Lewisburg side. If there is no correction for dip, the best building stone lies still higher than the section previously given at the sag below Rockport, on the Kentucky side, and will be found in the knob east of this sag.

Above the best building stone the rocks are more ferruginous, and just above them the *Fucoides* (*vellum?*) occurs. The so-called "iron stratum," of Locke, lies near the top of the hill, some four hundred and fifty feet above low water of the Ohio river; and one stratum near this horizon contains casts of shells and entrochites. There is estimated to be two hundred and eighty feet of freestone on the Ohio side, of which perhaps one hundred and forty feet may be fit for building purposes. An acre of land, underlaid by these building stones, at 12.5 cents per perch, would be worth, for the rock itself, 15,500 dollars, supposing it all available. Some good quarries have been opened, as I understand from Mr. Stratten, who worked the quarry, on Kinniconick. Dimension stones were to be obtained there from two feet to forty inches thick, and of all sizes, down to three or four inches. It is the whiter varieties of the knob freestone, of uniform tex-

ture, that are most to be relied on to stand the weather in external structures. The plan resorted to by the quarry-men to test their durability, is to expose the blocks in an inclined position to the action of weather and frost during the winter; if it be of durable material, no scales of disintegrated earth will be found removed from the under-surface, while on the contrary, if it is prone to decay, more or less of an earthy powder, or saline efflorescence, will be found to have collected on the under surface, which can be removed by running the hand along the lower face of the rock.

This rock, a few years back, sold for thirty-seven cents per cubic foot of dimension stones, and 12.5 cents per running foot, for caps and sills. The price is now a few cents higher.

The best quality of this knob freestone works free under the chisel, and is capable of being carved into fine ornaments. It is now extensively used in Cincinnati for the fronts of houses, and makes, by a judicious and careful selection of the rock, one of the finest and most durable, and most easily worked freestones that the country affords. Where favorable localities offer for reaching it, without too much labor and expense, and where it is of good quality, it can be made a profitable business to quarry it and prepare it for the markets along the Ohio river.

Along the valley of the Kinniconick a shaly slope is usually found over the benches of this knob freestone, towards the tops of the knobs, which is said to afford a soil similar to that of Johannisberg, in the Dutchy of Nassau, which furnishes one of the most celebrated Rhenish wines.

Already a small colony of Belgians have commenced establishing vineyards on the Kinniconick knobs, and vineyards have also been planted, in the same geological position, on the north side of the Ohio river, near Buena Vista, in Ohio. These vineyards are yet too young to afford vintage, but the success of these experiments is of the greatest interest to the inhabitants of the knobby region of Kentucky; since, if this soil proves to be as congenial to the grape as the Belgians anticipate, there is undoubtedly no better or more profitable application of this kind of land. It is doubtless a very different soil from that spoken of under the head of Bracken county, but nevertheless it may produce a grape which will afford good wine, since the soil of the

wine district of Malgue is described as being a schistose soil, such as may result from the disintegration of the shales over the knob freestone, mixed, probably, with enough silica from the subjacent freestone to make it loose and permeable, and with sufficient lime, derived from the subcarboniferous limestone, which may, at a former period, before extensive denudation took place, have capped these knobs, though now only visible in some portion of their southeastern range. It is to be confessed, however, that of all the soils at present analyzed, that collected from the upper part of the Salt river knobs has proved to be the poorest in the essential elements of fertility; but those from the eastern range of the corresponding geological formation may be somewhat differently constituted, from variations in the lithological character of the strata at localities one hundred and fifty miles apart. We shall look, therefore, with no small degree of interest to the results of the experimental vineyards in Lewis county.

Many of the vineyards of the Neckar are, I am told, laid out on variegated shales, only very partially disintegrated, which, no doubt, belong to the Lias formation of the kingdom of Wurtemburg.

Borings have been made for salt in the vicinity of Vanceburg, but with what success I am not informed. But since these borings were commenced, near the base of the junction of the magnesian limestones of Upper Silurian date, they must have passed through the encrinital beds belonging to the Clinton group, the twenty to twenty-five feet of marl underlying it, and then into the blue limestone formation; the character of the rock they penetrated was not favorable for obtaining strong brines.

The flinty magnesian limestone, near low water of the Ohio river, at Vanceburg, often affords efflorescences of sulphate of magnesia, and sometimes weak brines, but as this rock is only, at most, forty to fifty feet thick, it is not likely to afford any considerable store of salt.

The valley of the west fork of Salt Lick creek is based and flanked, as high up as its forks, by the yellow magnesian limestone, with its capping of black slate. In this valley a characteristic soil, derived chiefly from the former rock was collected, from Adam Bartram's farm. This soil represents a large portion of the soil of the Salt Lick valley. It has a peculiar light-yellowish-red cast. It is greatly improved by deep ploughing; and wheat succeeds well in it if thrown up into ridges, which seems to prevent its freezing out.

The yellow magnesian limestone is underlaid by a soft yellow argillo-magnesian rock; the light colored clay shale, beneath the latter, appears to rise or increase in thickness with the ascent of the valley.

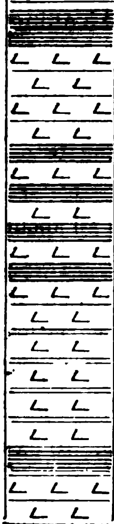
The following section was obtained, at the ascent of the hill leading to the Poplar Flats, beyond the horse mill:

187. Black slate, forty feet exposed.
147. Base of black slate.
Top of yellow magnesian limestone.
100. Base of yellow magnesian limestone, forty-seven feet exposed.
0. Soft yellow argillaceous rock with shales and light colored clay, in all about one hundred feet seen.

This is the great marl stratum of Adams county, Ohio, which is there one hundred and six feet thick. It forms three several varieties of soils. The sugar-tree soil, usually exists immediately under the overlying ledges of magnesian limestone, and is well adapted for wheat and corn, if not in too steep declivities. In such situations it is liable to extensive slides, forming the so-called "Cove Land."

Where the marl strata reach the surface, and form level tracts, removed from the out-crop of the magnesian limestones, it forms the "white oak flats," of inferior quality to the preceding. When denuded into conical mound-like eminences, it forms a kind of "glades" or "Bald hill," in which few trees grow; but the soil is congenial to the prairie dock, wild sun-flower, scabish, and rudbeckias.

SECTION OF ROCKS OF LEWIS COUNTY BELOW THE BLACK SLATE, DOWN TO THE BLUE FOSSILIFEROUS LIMESTONE.



40		Black slate of Devonian date 40 to 50 feet.
47		Yellow magnesian limestone forming benches or low cliffs.
100		Great marly strata with intercalated bands of calcareous rocks.
50		Flinty or cherty saliferous magnesian limestones with some marly partings; including, at the base encrinital, magnesian limestones; Clinton group.
20		Marly bed 20 to 25 feet.
		Top of blue fossiliferous limestones on the extreme western borders of the county.

This section represents the magnesian limestones, and associated marly beds, comprising the rocks of Upper Silurian date, with a small thickness of strata just under the black slate, which may, probably, be referred to the Devonian Period; a few feet at the base of the lower fifty feet of magnesian limestones belong to the Clinton group of New York.

There is still some knob freestone capping the first hill ascending to the west from the valley of Salt Lick towards Poplar Plains.

From here the magnesian limestone continues to ascend to the level of these flats, where it loses its capping of black slate. A soil was also collected from the Poplar Flats, near its western termination before descending to Cabin creek, where the upper members of the blue limestone came out, on the western confines of Lewis. This magnesian limestone soil was collected from the Hendrickson farm, where the poplar timber was originally intermixed with blue ash, buckeye, and sugar-tree, with an undergrowth of pea-vine and spice-wood. This soil is considered the best land of Lewis county, except the bottom land. The junction of the blue limestone and magnesian rocks, underlying the clay shale, is seen well on Cabin creek, with a few feet of cherty layers interposed between them, and without much marl intervening.

No magnesian limestone, that could be referred to the Clinton group, was observed here. The top of the blue limestone lies about one hundred and forty to one hundred and fifty feet below the table lands of the Poplar Flats.

The black slate and ash colored shale are the prevalent rocks in the hills around the Esculapian springs, which issue from fissures in this formation. For the results of the chemical tests applied to this water, see chapter on mineral waters.

Below the Esculapian springs, near Mr. Runion's store, the yellow magnesian limestone forms a bench, beneath the black slate, whence the so-called "Alum Spring" issues.

The knob which lies between the Esculapian spring and the heads of the north fork of the Licking, whence this stream indeed takes its rise, is composed chiefly of black and ash colored shales, which rise high up into this knob, upwards of three hundred feet above the springs. It has doubtless a capping of knob freestone, but little or no rock of this description was seen in the pass.

There appears to be a concealed axis of disturbance in this hill, which prevents one being able to estimate the true thickness of the rocks composing it, without more detailed examinations than I have yet been able to make.

FLEMING COUNTY.

A continuation of the range of the knobs, giving rise to the heads of the north fork of the Licking, in their southwest course, forms the northwest boundary of the lower sub-carboniferous rocks in this county, based on the black Devonian shale. The country east of these hills, immediately around Mount Carmel and Poplar Plains, is based on the yellow magnesian limestones. A portion of this group is referable to the age of the Clinton group of the New York system, and contains *Glyptocrinus plumosus* and both fig. 4 and 7 of Pl. A. 41 of Halls, 2 vol. Pal. N. Y.; also *L. depressa* and *O. circulus.*

East of Mount Carmel, the beds referable to the Clinton group are near the surface, underlaid by yellow magnesian limestone, with cherty segregations ten feet in thickness; which latter rests on marly and greenish clay shales, interstratified with an hydraulic looking layer; the whole reposing, in the hollows, on the blue limestone.

The belt of country occupied by the yellow magnesian limestone is only two to four miles wide, in the northern part of the county, and the Clinton member of it is quite thin, and so blended with the associate rocks that the line of demarkation between them is very obscure; the fossils, too, are few and imperfectly preserved, so that it is only by

very close observation that the identity of the formation is recognizable. The junction of the blue limestone with the clay shales, under the magnesian rocks, is marked by hornstone gravel, derived from an intervening layer or imbedded segregations, almost immediately reposing on the plano-convex beds.

The soil derived from the upper beds of magnesian limestones is of a brownish-red cast, like that around Danville, in Boyle county, but the growth is rather different—beech, walnut, sugar-tree, white oak, ash, and mocker-nut hickory. Wheat is apt to freeze out of the soil lying between Mt. Carmel and the base of the range of knobs; on this account the farmers of that vicinity have turned their attention to cheese-making, and several diary farms have been established with good success, in the neighborhood, chiefly through the enterprise of Charles Marshall. Some of them milk as many as seventy cows, and make one hundred and twenty-five pounds of cheese daily, of very excellent quality, which brings the highest price in the New Orleans market.

A soil was collected, for chemical analysis, from Mr. Marshall's dairy farm, where the growth is sugar-tree, walnut, ash, and buckeye on the slopes; under-growth, pawpaw. It is good corn, oats, and grass land; reposing on the yellow magnesian limestone, but has, probably, derived some of its argillaceous properties from the adjacent shales. It is not as quick a soil as the blue limestone soils which adjoin it, on the northwest part of the county, but it is said to stand drought better. There is a strip of flat, white-oak land, which intervenes between these two characters of soils, derived, apparently, from the interpolated clay shale. This soil, though considered the poorest land of Fleming county, is still capable of being made a productive soil by a proper system of drainage and cultivation. In its original condition it is too stiff and wet, so that both grass and wheat freeze out. It only occupies a very narrow strip of country, running northeast and southwest, between the sugar-tree, walnut, and ash lands, and the oak and hickory lands to the northeast.

All the part of the county around Flemingsburg is based on the argillaceous varieties of the lynx and occidentalis beds—the upper members of the blue limestone formation of this part of Kentucky.

Hillsboro' lies on the same formation as Mt. Carmel.

Seventy-five feet of blue limestone is exposed on the banks of Fox creek, near the crossing of the Owingsville raod, having a capping of

yellow magnesian limestone and clay shale. The lynx beds of the blue limestone extend down nearly to low water of the Licking, near Wyoming.

ROWAN COUNTY.

The whole of the northern part of this county, including almost the entire valley of Triplett creek, is occupied by the knob formation, the lower sections usually presenting the black slate, with a capping of knob freestone. On the Licking river, at the mouth of Triplett creek, and near the crossing of the Big Sandy railroad, there is an excellent opportunity of opening fine quarries of fine grained knob freestone, without much stripping. The ledges are from one foot eight to two feet or more, and appear to be of good quality, as they form bold projecting ledges along the declivities of the hills. Near the junction of the freestone and underlying shales there is some kidney ore, but not in as large quantities as in Bath, probably because the ash-colored shale, which usually forms the matrix of this ore, is not as well developed as in Rowan county. The black slate extends nearly up to the freestone, and is of great thickness—probably over one hundred feet—but I obtained no good measurements of it on Triplett's creek.

Several advantageous places present themselves, on the range of hills bordering on Triplett's creek, for opening quarries in the freestone, as well as on the Licking river.

Towards the heads of the Christy's branch of Triplett creek a bench of the sub-carboniferous limestone shows itself near Kirk's Horse Mill, about ten to fifteen feet above the bed of the creek; and a little higher up, on the same creek, three to five inches of coal crop out, in the bank of the creek, with a thin clay parting and roof of grey shale. I have not yet seen any thick, workable beds of coal in the southern part of this county. Near the confines of Carter, there is said to be an eighteen-inch coal, on the head of Tygert's creek, in the vicinity of the Big Spring; and one about the same thickness on Caney creek.

The high hills on the confines of this county and Morgan, are composed of the shales and conglomerates, at the base of the Coal Measures, with considerable surface indications of iron ore, but rather of a silicious character. It is possible, however, that some good ore may

be found in the ferruginous shales immediately over the limestone, but no sections were exposed to afford an opportunity of forming a correct opinion in regard to these deposites of ore. On the slopes of the ridges and hollows there is some very fine large oak, poplar, and some good pine near the high summit levels of the country.

BATH COUNTY.

Owingsville stands upon high table land, underlaid by the yellow magnesian limestone, of which the upper beds are of Devonian date, the lower of Upper Silurian date, to which period the middle marl beds, with intercalated calcareous rocks, also probably belong. The encrinital layers beneath this are of the age of the Clinton group of New York. These latter beds rise high into the hills about a mile east of Owingsville, and the space between them and the beds of unequivocal Lower Silurian date has increased from ninety to one hundred feet, as exhibited in the following approximate section:

100. Encrinital yellow magnesian limestone belonging to the Clinton group of New York.
90. Chert beds.
85. Top of clay shale.
Chert slope.
75. Ash-colored clay shale.
60. Ash-colored clay shale.
35. Flag beds of magnesian limestone, interstratified with clay shale.
25. Clay shales.
Earthy beds of magnesian limestone.
0. Top of blue limestone seen.

On the east side of the table land from eighty to one hundred feet more of magnesian limestone and clay shales are superimposed, on the upper member of the above section. The lowest of these is soft red magnesian limestone, covered by greenish clay shale, over that heavy bedded magnesian limestone, running up into flaggy layers; over this another clay shale, with chert masses on top. It was in this latter where a *Zaphrentes* was found, apparently of the same species as a large one found on the falls of the Ohio, only more prominently wrinkled.

All the streams around this table land cut into the upper beds of the blue limestone.

The rock foundation on which old Slate Furnace is built is of this rock, but the yellow magnesian limestone has been employed in its construction. The ore formerly worked at this furnace is associated with the magnesian limestone of the age of the Clinton group, and some of it possesses an imperfect oolitic structure, like the equivalent ore found in Tennessee and elsewhere; but it is for the most part more silicious than is usually found at this geological horizon. From the surface indications there appears to be abundance of it, but it will, no doubt, make a rather high, close-textured iron. The old furnace, where this ore was formerly worked, went out of blast in 1838, when the lease expired, after having been in operation forty-seven years, and has not been in blast since.

A soil was collected for analysis immediately over the ferruginous deposites of the Clinton group of this county, the growth being scrub oak and hickory.

South of these ferruginous beds there is a tract of flat clay, oak, and hickory glades, which, from the stubborn nature of the soil, does not seem to have attracted the attention of many farmers. These glades extend for nearly a mile and a half along the road from the old Slate Furnace to the Olympian Springs, beyond which is the base of knobs, with their usual foundation of black slate, in which rock the mineral waters of the Olympian Spring issue.

There is, however, a very fine Chalybeate spring, that comes out from below a heavy rugged bench of magnesian limestone, on the north side of the knob, about a quarter of a mile from the Olympian Springs, and no doubt runs over the extension of the ferruginous deposit heretofore spoken of. One mile beyond is a strong saline water, containing large quantities of Epsom salts.

To the east of the Olympian Springs, on Mud Lick creek, the extension of the black slate was traced to the Sudduth Springs.

Some little appearance of knob ore was observed in the grey shale over the black slate on the waters of Mud Lick, the quantity increasing gradually to the south. On Salt Lick and Clear creek there are some very fine beds both of block and kidney ore. The surface indications, through this part of Bath, indicate bodies sufficient to supply a furnace, and that of ore which will make a good soft grey iron.

Further south, towards the heads of Clear and Stone Quarry creeks, after rising over the argillaceous freestones covering the black slate,

about two-thirds of the height above the stream, a bench of the sub-carboniferous limestone can be traced, running through the hills. Immediately on this reposes a very universally distributed bed of iron ore, in conformable stratification with the limestone, with sometimes six to eight inches of ochreous earth between the solid ore and the surface of the limestone rock. The immediate matrix of the ore is grey, yellow, and pink clay. When the ore lies *immediately on the limestone*, as it sometimes does, without the intervention of these earths and clays, it is then not unfrequently, in the language of the ore digger, "burnt out," by which I suppose is meant, less productive in its yield of iron. By an infiltration, perhaps, of part of the iron into the pores and fissures of the limestone, and a partial conversion of the carbonate of lime into carbonate of iron, such a transposition of the oxide of iron may take place.

This bed of ore varies from one foot to eighteen inches, rising sometimes as high as three or even four feet.

Fifteen feet above the ore bed is the lowest bed of coal, in this part of the eastern coal field, which, on the head of Clear creek, is four feet, with a clay parting of one foot, which reduces the thickness of actual coal to three feet. The upper member is one foot ten inches; the lower member I was not able to measure myself, from the influx of water into the bank where the coal has been partially opened. It is said, by those who have dug it, to be twelve to fourteen inches. This coal lies about twenty-five feet under the base of the conglomerate that crowns the hills on the southern confines of Bath county; it is here located within six miles in a direct line from the Lexington and Big Sandy railroad, and even within three or four miles, if the route should be preferred south of Olympian Springs, which would then pass within two or three miles of the Clear creek furnace.

The same bed of coal appears in the southern corner of Bath county, on the waters of Indian creek, where it has been fairly opened by Morris McCormick. Here I had the best opportunity of seeing and measuring the coal. It is two feet nine inches in thickness, and lies fifteen feet above the top of the sub-carboniferous limestone, and seventy feet under the base of the conglomerate or millstone grit. The roof is a dark-grey shale, with some imperfect impressions of slender pointed leaves, probably belonging to Lepidodendrons, fifteen inches in thickness, over which are reddish and yellowish grey shales. The floor

is a dark, gritty, indurated shale, or silicious fire-clay. The quality of the coal is good. It has not yet been analyzed.

Last year Dr. Darby, of Lexington, handed a specimen of ore to Dr. Peter, which proved, on analysis, to contain a considerable per centage of copper. This ore was said to have been found in the debris of Clear or Stone Quarry creeks, which empty into Salt Lick creek, in Bath county; and, if so, must have been washed from the head of these streams. When in Bath county I investigated the source of this ore as closely as the general nature of the examination at that time instituted would permit, and am led to the belief that its source is, in all probability, connected with the beds of iron ore heretofore mentioned as accompanying the range of the sub-carboniferous limestone. Some of the ore I found to possess a peculiar dark appearance, as if it might contain some black oxide of copper. Some of these specimens have been collected for chemical analysis; two varieties have already been examined, without, however, discovering any appreciable quantity of copper.

All that part of Bath county south of the eastern tributaries of Flat creek, is based upon the blue limestone, and, principally, on the argillaceous lynx beds. One mile east of Sharpsburg, over these beds, a set of soils were collected for chemical analysis, from General Sudduth's farm, where the soil has rather a puce tint; growth, locust, black walnut, black and blue ash, wild cherry, and some white oak; undergrowth of cane. This soil is about equally productive with the best blue limestone soils for corn, wheat, and oats; though it does not produce quite as fine crops of hemp as the heavy walnut land, in the south and southwest of Sharpsburg. Samples of the best hemp soil of Bath county were collected from Mr. Stevens' farm, in the south west part of the county.

MONTGOMERY COUNTY.

The northeastern part of this county is derived from the chætetes, lynx, and occidentalis beds of the blue limestone, and supports a growth of walnut, sugar-tree, ash, oak, and hickory. The country is level, and laid off in extensive stock farms. The sub-soil is red. It is excellent land for almost all kinds of grain, and no doubt will prove to be based on an almost inexhaustible store of the elements of fertility in the red under-clays, which, from their general appearance to those of

Fayette county, will probably give by, chemical analysis, a similar result.

Sets of soils were taken, for analysis, from Mr. Apperson's farm, in the vicinity of Mt. Sterling: growth, black walnut, sugar-tree, shellbark hickory, wild cherry, and black locust. The nearest underlying rock is the bluish-grey argillaceous variety of the lynx beds of the blue limestone formation. The beds of this formation, in the neighborhood of Mt. Sterling, are generally thin-bedded, and not well adapt- for architectural purposes, particularly since there is a considerable portion of argillaceous matter in their composition. The best buildingstone of this vicinity is a grey sub-crystalline, limestone, that lies low in the bed of the creek, beneath the more argillaceous beds above.

Two miles south of Mt. Sterling the red under-clay has considerable silicious gravel disseminated.

The boundary between the blue limestone and overlying magnesian limestones, at the confines of this county and Clarke, is marked by the abrupt dislocation and tilting of the strata previously mentioned, where the rocks dip to the south at an angle of 11° to 13°. At the commencement of this strong inclination of the strata, a kind of dyke, or wall of irregular fractured limestone, intervenes. North of this the blue lynx beds have but a very slight dip to the southeast.

Benches of the yellow magnesian limestone occur in the bank of Lulbegrud creek, immediately above the tilted strata of blue limestone, partaking of nearly the same inclination to the south. Here the beds, referable to the Clinton group, are only visible about forty to fifty feet above the top of the highest beds of blue limestone. The range of the knobs to the south is in view of this place, and the black slate is close by on the top of the yellow magnesian limestone. This is near Levee.

Three miles above this place there are rolled masses of conglomerate, mixed with the debris of the black slate and knob freestone.

POWELL COUNTY.

Red river has cut sections into the black slate, along the greater part of its course, from above the forks to the abrupt bend at the corner of Estill, while the hills are capped with the knob freestone. Near the mouth of Wolf-pen and Chimney the Coal Measures commence, with a twenty-three to twenty-five-inch coal near their base.

The same bed also occurs up the valley of Cow creek. This bed has supplied coal for the Red River Forge and Rolling Mill; but great difficulties have been encountered in running it down in boats, since it has to be brought, during the highest freshets, when, in consequence of the number of rocks in the bed of the river, and the cross currents from the lateral torrents rushing in from the tributaries, many boats are wrecked in the descent.

The knob freestone, where it was seen in the hills bordering on Red river, is thin-bedded and schistose. The ash-colored shale beneath is in great force—about one hundred and forty feet thick, with some disseminated carbonate of iron. At one section exposed between the Forge and Stanton five bands of ore were exposed thus:

Dark shale;

Band of carbonate of iron, three to six inches;

Space with shale, eighteen inches;

Band of carbonate of iron, two to four inches;

Space with dark shale, eight to ten feet;

Band of carbonate of iron, two to four inches;

Space with dark shale, four feet;

Segregation of small kidney ore;

Space with shale, three feet;

Band of carbonate of iron, two to six inches;

Space with dark shale, three to four feet.

Borings have been made through the ash-colored and black shale, and interposed hard band of sandstone, and a brine obtained from which, for sometime, fifty bushels of salt were made in a week's operation; however, the water was not in sufficient quantity to afford this supply but for a limited time, and the enterprise was abandoned.

On Cow creek, which empties into the south fork of Red river, subcarboniferous limestone is separated into two members by an interposed grit stone, in all nearly two hundred feet in thickness. The high range, on the confines of this county and Estill, are capped with the gritstones and shales at the base of the Coal Measures.

ESTILL COUNTY.

On the headwaters of Miller and Cow creek, tributaries of Kentucky river, extensive beds of iron ore overlie the sub-carboniferous limestone, in the same manner as has already been described in Bath coun-

ty. The ore is partly in the form of kidney ore and partly that of block ore; principally carbonate, but mixed more or less with limonite. The old Furnace, on the head of Miller creek, is supplied with ore from this geological horizon. Here, as in Powell county, the sub-carboniferous limestone is divided, by nearly one hundred feet of sandstone, into two, if not three, members—the upper, grey; the lower, white. The underlying knob freestone is about two hundred feet thick, and is, for the most part, thin-bedded and schistose. The ash-colored shale below is about the same thickness as in Powell county; and black slate about one hundred feet. An attempt was made, near the head of Hardwick's creek, to get salt water by boring. These borings were carried about one hundred feet through the black slate, the same distance through the underlying magnesian limestones, and two hundred feet into the blue limestone. Only a small quantity of weak brine was obtained.

The "Cottage Furnace," lately erected by Messrs. Mason and Wheeler, is supplied with ore from the high land lying in the divide between Cow and Miller's creeks. It lies over the sub-carboniferous limestone, and can be reached in many places by about ten feet of stripping. The average thickness is from nine inches to one foot, and it lies about fifteen to twenty feet below the overlying cliffs of sandstone, at the base of the Coal Measures, which cap these high ranges of hills, and sometimes form bold escarpments, one of which, at the head of Hardwick's creek, is known under the name of the "State-house" Small quantities of kidney ore are sometimes found over the lower ledges of sandstone.

At one of the openings into the ore, over the limestone, the bed measured one foot ten inches, with three wedge-shaped streaks of clay intervening, reducing the thickness of the ore to about one foot four inches. At the California ore bank the ore is more highly oxidized, and often of a deep reddish-brown. The sandstone over this ore bank is a very white quartzose variety, fit for making glass.

The summits of the ridges are about six hundred feet above the black Lingula shale. The overlying ash colored shale contains considerable beds of ore, lying some four hundred feet below the upper ore banks, over the limestone. Samples of the ores of Estill, Powell, and Bath have been collected, but time has not yet permitted of their chemical analysis.

The following section will convey a general idea of the succession and approximate thickness of the geological formations in the eastern part of Estill:

White, yellow, and pebbly sandstones at the base of the Coal Measures, capping the ridges;

Shales with coal? ten to fifteen feet;

Ferruginous shale;

Rough ore;

Shale;

Lower main ore, nine inches to one foot four inches;

Upper beds of white and buff sub-carboniferous limestone;

Intercalated sandstone;

Limestone, (grey beds;)

Intercalated sandstone, one hundred and ten feet;

Lower white beds of sub-carboniferous limestone, ninety-five feet;

Knob freestones, two hundred feet;

Ash colored shale and knob ore, one hundred and forty feet;

Black shale, one hundred feet, extending beneath the drainage of the country.

Frequent indications of iron ore were seen in the horizon of the ash colored shale, between Hardwick's creek and the forge, particularly about three miles from the latter place.

Through a considerable portion of Estill county there is an earthy calcareous rock, under the black shale, that probably has hydraulic properties; its position is seen by the partial section, four to five miles southeast of the forge:

Black shale;

Dark (hydraulic?) rock, two to four feet;

Space with shale and clay, five feet;

Upper bed of yellow magnesian limestone, two to three feet;

Cherty bed of yellow magnesian limestone, four to five feet.

On the farm of Scarly King, six miles northeast of Irvine, small quantities of sulphuret of copper and iron are found disseminated in an orange-yellow magnesian limestone, either of the age of the Clinton groupe, or in rocks of the same composition immediately under it. It is found in a hollow where there seems to be either a depression of the strata, or it is in the line of an imperfect fissure.

This ore is too sparingly disseminated in the surface specimens to be of much value. Better specimens might, probably, be obtained by sinking a shaft; but the amount of shaly material, compared with the solid limestone in the strata which would be passed through, is unfavorable for the formation of a good metallic vein; nor could I find any evidence of any important axis of disturbance or dislocation in the immediate vicinity, or the debris of veinstones, which would give encouragement or justify much outlay even in proving the ground. A good deal of the same rock in the vicinity has light-greenish-grey incrustations and disseminated particles; but from a partial chemical test of one specimen, brought to this laboratory, it seems to be a green earthy matter, containing no appreciable quantity of copper, and even the small particles of bright disseminated yellow sulphuret appear to be mostly yellow iron pyrites, at least, a small portion, broken from a specimen and tested, did not give the re-action of copper. The best specimens were, however, sent to Dr. Peter, who will be able, next season, if the survey is continued, to give them a closer examination.

The same orange colored magnesian limestone, as at King's, is seen a mile from Irvine, dipping about two degrees to the southeast, and the rocks of the Lower Silurian period seem to be not far off, as some imperfect fossils referable to that date were picked out of loose pieces of chert; but no rock of this age, was observed in place, even in the deep cut of the Kentucky river at Irvine. Here the following strata were observed, between low water of the Kentucky river and the top of Rock House knob, capped with sub-carboniferous limestone:

Feet.

648. Top of Rock House knob 78 feet in thickness.

576. Foot of do., and top of Knob Freestone; 414 feet in thickness, with perhaps some intercalated shales.

176. Foot of Knob Freestone and junction of shale; 67 feet thick, limestone shale.

100. (Hydraulic rock?)

90. Top encrinital magnesian limestone.

88. Limestone shale.

87. Top of yellow magnesia limestone.

82. Base of do.

67. Dark green shales, with thin band of carbonate of iron.

25. Grey shale, with three streaks of carbonate of iron.

0. Low water Kentucky river.

The strata dip down stream to the northwest, which bring the magnesian limestone, at 90 feet in the above section, down to within a few feet of the water, above the mouth of White Oak creek, where it will afford some excellent building material, very conveniently situated for shipment on the Kentucky river.

The rocks situated between the magnesian limestones and the black slate, splitting with a conchoidal fracture, may, probably, afford hydraulic cement at several places near the Kentucky, river, both above and below White Oak creek.

A soil was collected from the immediate debris of the black slate, where, in fact, the corn was actually growing in the interstices between fragments of this rock, and looking very promising in July, 1857.

Crooked creek flows chiefly on the black shale, with cherty magnesian limestone in the low situations. Drowning creek, on the line between Estill and Madison counties, near the foot of "Dug Hill," has cut into the magnesian limestones. The Dug Hill is mostly black slate, over which there is a sandy debris, apparently derived from the grit-stones at the base of the coal measures, which supports a growth of pine and oak, forming a peculiar feature in the landscape.

It is difficult to account for the disappearance here of the mass of knob sandstone, which is about 400 feet in thickness on the other side of the Kentucky river. This kind of country extends north nearly as far as the mouth of Drowning creek, getting wider and lower in its northern extension.

It appears as if powerful currents must, at one period, have swept through this portion of Estill; carried away many hundred feet of strata, and brought down debris from the coal measures, the outliers of which extend to the waters of Buck creek, Station Camp, and Rock Lick, in the southern confines of the county. This current probably came through the gap in the mountains, where the waters of Drowning, Locust, and Red Lick interlock, which is the only low pass in this part of Estill, from the southern into the northern settlements.

At Knob Lick the summits are capped with sub-carboniferous limestone, while the creeks, at the base, flow over black slate. The ore found in this vicinity, consists merely of spherical segregations in the black slate, chiefly composed of carbonate of lime and sulphuret of iron, with, perhaps, small quantities of sulphuret of zinc, and possibly a little lead; but I did not see any of the latter, even at the lo-

cality where it was said to have been found. But, even if some lead ore has been found, the mode of its occurrence, and the rock in which the segregations are imbedded, show that no body of ore can be obtained in this position. If there are any veins of lead ore in the Knob lick country, they will not be found in the black slate, but rather in the sub-carboniferous limestone; as yet, however, the only evidence of its existence, even in that latter formation, are merely small pieces of sulphate of barytes, occasionally picked up, which in other portions of the slate, is sometimes the vein stone, associated with galena; but fluor-spar is its more frequent associate, in the sub-carboniferous limestone; therefore, the presence of this mineral would be a more favorable symptom than the sulphate of barytes.

A line of disturbance runs through the Knob lick country, shown by the sudden reversal of dip, not far from Leroy Tudor's. The sections along Red Lick, exhibit the black slate, overlaid by the ash-colored shale, as far up as Andrew Garrett's, which is as high as it has yet been personally explored by me up to this time.

In the hills forming the divide, between Red Lick and Rock Lick, a bed of coal, said to be three or four feet in thickness, occurs above the sub-carboniferous limestones, from which some coal has been obtained for the use of the blacksmiths. A part of this coal, on Red Lick, has a cannel structure. On the War fork a thin coal of eight inches lies close to the limestone. These, and a bed of coal on the waters of Buck creek, are the most northern outliers of the Coal Measures of Estill. It is probable that more or less iron ore will be found over the sub-carboniferous limestone, in the southwestern part of this county; but this is still an unexplored region.

Small quantities of sulphuret of zinc occur in the rocks of Station Camp creek.

Ponderous masses of the yellow magnesian limestone underlie the knob shales, forming a bench of fifteen to eighteen feet, near William Moore's, which will afford some excellent building material.

Considerable quantities of carbonate of iron are disseminated in the ash colored clay shale of Station Camp creek. All the highest knobs along Station Camp creek have a capping of limestone.

Borings for salt have been made on Miller's creek, a few miles above its mouth, and some salt water obtained; with, I believe, the same

or similar results as those to the attempts made on Red river, near its forks, in Powell county, already mentioned.

Throughout Estill county the knob freestone is characterized by the so-called Curtain fucoid, (*Fucoides vellum*,) which occurs in the Waverly sandstone of Ohio, and the Ithaca group of New York.*

MADISON COUNTY.

The "red-bud lands" of this county are based upon the yellow magnesian limestone, or the slopes immediately under it.

Debris of the Coal Measures—of sandstones resting on the black slate—such as has been mentioned as occurring on the "Dug Hill," in Estill county, extends a short distance into Madison county, between Drowning and Muddy creek, with yellow pine growing on it.

Two miles to the west of the Irvine and Richmond turnpike, a range of knobs extend several miles further north, down the Muddy creek valley. The turnpike is metaled, for a great part of the distance between the Kentucky river and Muddy creek, with a black limestone shale, underlying the black slate which, when not too argillaceous, makes a good dry solid road, and is a cheap material, since it is easily obtained close to the road, and breaks with facility under the hammer. Locally the same geological horizon, in some parts of this district of Madison county, will afford hydraulic cement rock.

Characteristic specimens of the red-bud lands of Madison were collected for chemical analysis, in the vicinity of Elliston. It is a fertile soil, especially adapted for corn and tobacco, and gives a yield of fifteen to twenty bushels of wheat to the acre. New ground will yield forty bushels to the acre. It is sooner exhausted than the blue limestone soil, and suffers more from dry weather. The growth, besides red-bud, is white oak, walnut, cherry, and some ash and sugar-tree. The original undergrowth was cane and elder bushes.

There is a considerable tract of flat, slashy, crawfish land, between Elliston and Richmond, based on the ash colored shale or black slate. This land is much disposed to grow up in briars. The principal growth is white oak. By a proper system of drainage this land can be greatly improved, and, when subdued, would, undoubtedly, be found to be durable soil, well adapted for grass and certain kinds of small grain.

* See Lardner Vanuxem's Report on the 3d District of N. Y., page 176.

About two miles east of Richmond there is a very abrupt change in the soil from this white oak land, to a belt of rich walnut and locust land, that circumscribes it on the west and south, resting on the outcrop of the yellow magnesian limestone, with the intervention of a ferruginous under-clay, full of gravel iron ore.

Richmond stands on the thinly stratified upper beds of the blue limestone, of greenish and bluish-grey tints, earthy in their structure, and affording, by decomposition, a rich productive soil. One of the beds is rich in fossil shells, belonging so the species *L. planumbona*. The soil produced from this bed, known familiarly under the name of "cockle bed," supports a growth of red oak, and is quick, lively, productive land.

In the west and northwest part of the county a very extensive business is carried on in fattening hogs on clover, rye, and corn, especially in the broken lands bordering on Silver creek. I have not yet examined this part of the county, and cannot, at present, say what particular members of the blue limestone formation prevail in that section of the country.

The Coal Measures in this county are confined to the upper portion of the high range known as the "Big Hill," in the southern part of this county, where Rock Lick and Roundstone creeks take their rise.

LINCOLN COUNTY.

Long's branch flows nearly along the axis of elevation of the Silurian rocks, and in the valley of this creek is located the tongue of land which forms the entering wedge which parts and deflects the lower sub-carboniferous strata, whence the two distinct ranges of these strata diverge to the east and west, in directions hitherto-fore described. From the northwestern base of this wedge a fine body of arable land stretches out, in an eastern direction, by the Crab Orchard and Stanford road, towards the confines of Garrard county, based on the yellow magnesian limestones of the Upper Silurian and Devonian? periods, with here and there an admixture of black slate soil, where the spurs of the ridges project and overlap that formation. Logan's creek has, however, cut down through the variegated magnesian limestone of the Upper Silurian period into the upper beds of Lower Silurian date, exposing to view the chætetes and lynx members of that formation, near the base of the section.

At the old Logan Station the lower rocks exposed are the cherty beds of magnesian limestone, referable, in part, perhaps, to the Clinton group, overlaid by the variegated earthy limestone, some of which may possess hydraulic properties. Some fragments of black shale are seen here on the surface; and half a mile on the Liberty road, near Arsoff's spring, it is in place. Heavy masses of the brown and buff magnesian limestone appear here suddenly thrust up on the south, to a higher level than the black slate on the north.

The whole bed of Flat Lick is of the black slate, with low ledges of the same on its banks, over which is the ash-colored shale, with large quantities of disseminated carbonate of iron. To the southwest, at the head of the Lick, the black bituminous shale seems to have been on fire, and half roasted the ore above into a dark-red oxide, ready prepared for the furnace.

Flat Lick itself is an extensive depression of many acres, in part trodden down, and perhaps, to some extent, eaten out by the herds of wild animals that formerly made it a place of general resort, either for the purpose of licking the saline efflorescence, or sipping at mineral waters that formerly oozed out from the interstices of the shale. There are four or five distinct bands of carbonate of iron here, interstratified in the shale in a vertical height of five or six feet, which will average six inches in thickness. This locality, and the vicinity of Flat Lick creek, would be worthy the attention of the iron master, as the ore has been shown, by chemical analysis,* to contain 30.77 per cent. of iron, and to be of such a composition, as to require but little addition of limestone to flux it, while it only contains 0.21 of Sulphur; tons of this ore are lying strewed on the surface, left by the disintegration of the enclosing shale, which is of the very same date as that which, in Bullitt and Nelson, have yielded such abundance of ore suitable for the manufacture of the toughest and softest iron. In Lincoln county it could be stripped with less expense than in these counties. Fifteen quantitative chemical analyses of saline mineral waters, from Lincoln county, will be found by reference to pages 235–242, inclusive, of the preceding volume of this report.

At Turnersville rocks of Upper Silurian date are exposed; and in the hill, one mile southwest of this place, the upper beds of the blue

*See page 243 of volume 2, of this report.

limestone may be observed, extending half-way up the hill, overlaid by a thin-bedded earthy calcareous rock. These, with the cherty and geodiferous beds, prevail for one and a half miles on the Liberty road; the black slate reappears near the Casey line.

BOYLE COUNTY.

The stratification on the eastern part of the county will be seen, by consulting the section already given on Dick's river, under the head of Garrard county.

Danville is located on the upper beds of the blue limestone. The soil over this formation, which was taken for chemical analysis, was collected from Thomas Reid's farm. The nearest underlying rock is the modesta beds of the blue limestone. The growth is sugar-tree, hickory, ash, and some walnut. The sub-soil is a dark-brownish-red clay, which will, in all probability, show a large proportion of mineral fertilizers in its composition, as does also the soil, which partakes of the same appearance.

The surface exposure of the magnesian limestones which intervene between the blue limestone and black slate, is very much contracted in Boyle county. Their place seems to be occupied almost entirely by a geodiferous marly shale, which flanks the base of the knobs ranging along the southern borders of the county; on this, a few feet of mottled geodiferous (magnesian?) limestone reposes.

Near the base of the Pine Knob, at Wm. Caldwell's, the lynx beds of the blue limestone lie within ten to fifteen yards of the edge of the black slate. There is evidently an abrupt fault and dislocation, running along the northern base of this range of knobs, for the strata at the above locality were observed to dip 7°, a little east of south, while only two or three feet of hydraulic looking limestone, and about five feet of magnesian limestone, can be seen between the lynx beds of the blue limestone and the black slate, whereas, in this space, we usually have, in counties not far distant, between one and two hundred feet of intervening rocks, occupying a belt of country several miles wide.

The Knob Lick, on the southern edge of this county, is almost a counterpart of the Flat Lick, previously described under the head of Lincoln county, except that it is not as much denuded, so that the ash colored shale is only gullied down to the black slate, which shows it-

self at the base of a labyrinth of bald knobs, some of which rise with a very abrupt slope to the height of ninety-five to one hundred and ten feet.

Considerable carbonate of iron is also disseminated here in the ash colored shale, at forty and ninety feet above the surface of the black slate, but not in as great abundance as in Lincoln county.

From the Pine Knob, which is about two hundred and thirty feet above the surrounding level country, there is a commanding and very extensive view. As the deep cuts of the streams are, from this elevated position, imperceptible, the whole district to the north has the appearance of an extensive plain, bounded on the south by the range of knobs, which sends out spurs three or four miles to the northwest.

The lower one hundred feet of the Pine Knob is, probably, composed of the ash colored shale, resting on black slate, though these are almost entirely hidden from view by vegetation, the upper part consists of the soft freestone, which is here almost a mudstone. The whole hill has weathered into a sharp conical form—the surface on the top being hardly sixteen paces across.

From the deep cuts of Dick's river to the summit of this knob, the sections of Boyle have laid bare rom two hundred feet down in the Kentucky river marble to the middle of the sub-carboniferous sandstone, with the exception of a portion of the rocks of Upper Silurian date, which appear to be concealed from view in the step of the above mentioned fault.

In the neighborhood of B. Wright's the knobs afford some tolerable building material, which has been wrought into gravestones and monuments; associated with this rock, in the same neighborhood, there are two or three feet of grey limestone, and a close textured silicious rock, almost fine enough for whetstones.

At Perryville, in the west part of the county, the heads of Chaplin creek have cut down, first through a concretionary bed, and then a dark obscurely crystalline grey limestone, reposing almost immediately on the Kentucky river marble.

The Rochester Springs, of which the proximate analysis is given in the chapter on mineral waters, issues from beds of the blue limestone, lying near the junction of this formation with the Kentucky river marble. The same strata form the surface rock in the western part of Boyle county. The lower layers, in the bed of some parts of Chap-

lin creek, are remarkable for their dark color, being nearly of as deep shades as some of the Trenton and Black river limestone of the state of New York.

CASEY, RUSSELL, CUMBERLAND, AND MONROE COUNTIES.

The geological characters of these counties have these features in common: that the deepest cuts of the streams have exposed the upper members of the blue limestone formation, while the hill-sides present sections of the lower sub-carboniferous rocks, reposing on the black slate. The area of the blue limestone is quite limited, the diversity of soil great, and the surface, for the most part, broken, or rather scooped out into abrupt slopes along the courses of the streams.

In these counties the lower sub-carboniferous strata have assumed a more calcareous character, presenting, usually, limestone shale in the place of the ash colored shale and lower bed of fine grained freestone, while the black slate seldom exceeds thirty or forty feet, and the strata intervening between the black slate and blue limestone are but little thicker.

CASEY COUNTY.

The highest points of land in this county lie towards its southeastern confines, adjoining Pulaski county, at the heads of the branches which are the sources of Red river. The black slate, at the base of their knobs, where I had an opportunity of measuring it, is forty feet in thickness: i. e. near the Liberty road, six or seven miles from Burton McKinney's. Here it is overlaid by shales and earthy schistose sandstones. Near the line between Casey and Lincoln counties, some measurements were obtained, on the hydraulic, mottled and variegated magnesian limestones, under the black slate, and they were found to be there about thirty feet, resting upon thirty feet of rocks, also apparently somewhat magnesian, but which, probably, belong to the Lower Silurian period; these, in the lower cuts, are associated with soft reddish-grey and ash colored marly clays. In a creek, just below, the rocks are much disturbed; the earthy limestones were seen dipping at an angle of 20° nearly west, while the adjacent blue limestone had a nearly reversed dip.

Two or three miles from Liberty the rocks, at the junction of the blue limestone, are full of *Favosites basaltica*.

Twenty-five feet of black slate is exposed above the waters of Green river, at Liberty, overlaid by grey and greenish shale. At thirty-five feet above the river, on a level with the town, there are loose slabs of encrinital limestones. This limestone was found in place, interstratified with the green shale, in the lower section of a knob, southwest of Liberty.

Borings for salt have been made in the Green river valley, not far from Liberty, and some salt water obtained at sixty-two and seventy-eight feet; the strongest being at seventy-eight feet, from which some salt was made, but not in sufficient quantity to make it profitable.

The knobs in the neighborhood of Liberty are about two hundred feet high. Their summits are strewed with sub-carboniferous chert, while sixty feet of the base is mostly ash-colored shale and argillaceous freestone. The encrinital limestone lies about fifty to sixty feet above their base. This limestone is worthy the attention of the inhabitants of the county, as the country around Liberty has been hitherto supposed to be destitute of limestone, and if not pure enough for building purposes would, at least, be valuable for improving the adjacent sandy and clay lands.

In the south western part of the county in the vicinity of Ben. Austin's, is a labyrinth of short steep hills, composed mostly of black slate and sub-carboniferous chert. The black slate here measures forty feet in thickness, and is underlaid by an encrinital limestone, with chert segregations.

The stiff, spouty, clay lands of this and the adjoining counties would be very much improved by draining and liming. Lime can be obtained much more coveniently than has been supposed, either from the calcareous rocks under the black slate or in the knobs above the black slate.

Goose Creek Knob is about three hundred feet above Green river at the mouth of Goose creek. Little Goose Creek Knob is about two hundred and forty-four feet by cistern barometer, and two hundred and forty-two by syphon barometer. There are several chert beds near the top as presented in the following section:

Section of Little Goose Creek Hill, near Ben. Austin's, dip about 1° south.

244. Brown mudstone and chert in loose blocks, 20 to 25 feet.

220. Do., 25 feet.

150. Two chert beds, each six inches thick.

Brown mudstone, 1 foot.

149. Brown mudstone and chert bed, 1 foot 6 inches.
148. Brown ochrey mudstone, 1 foot.
146. Chert bed, 1 foot.
144. Mudstone.
130. Bottom of chert bed, 3 feet.
128. Chert bed, 8 inches.
125. Chert bed, 2 feet.
123. Chert bed, 1 foot.
120. Chert bed, 6 inches.

Space with schistose argillaceous sandstone and grey and green shales.

45. Black slate.
5. Limestone with chert nodules of Devonian date containing *S. curutiones*.
0. Level of Goose creek at Ben. Austin's.

RUSSELL COUNTY.

After ascending Little Goose Creek Hill an extensive table land commences, near the edge of this county, and extends in a southwest direction to Jamestown. In a north direction this table land spreads out from the heads of Goose creek, in Casey county, to the heads of Wolf creek; on the southwest from the descent of Crider's Hill to Butler's creek; on the west to the heads of Russel creek; on the north to the breaks of Green river and the head of the Sulphur fork. Fully two thirds of the soil of this table land is of a light silicious character; the other third is based on a red clay. This high land has been protected from the degrading action which most of the surrounding region has suffered, by two lithological peculiarities which the sub-carboniferous rocks underlying this plateau possess, in Russell county, viz: the hard beds of chert, interstratified in the upper part of these hills, and the limestone shales, over the black slate, which take the place of the ash-colored shale; both materials being harder and less liable to disintegration than the strata which usually replace them.

This table land, from the water-shed between Green and Cumberland rivers, is elevated one thousand and seventy feet above tide water, and about six hundred feet above the Cumberland river, where it intersects the state line between Kentucky and Tennessee, and about six hundred and eighteen feet above Green river, at the mouth of Little Barren river, and about five hundred and seventy above Green river at Greensburg.

Descending from this table land to Crocus creek, on the Creelsboro' road, a section of thirty-five feet of grey, thin-bedded, geodiferous, subcarboniferous limestone is exposed. The upper layers schistose, and most of it earthy and dark colored. Two miles further on this road a good section is exposed, on Crider's Hill, descending a stream of the same name.

Section on Crider's Hill.

170. Hard reddish-grey limestone, 5 feet.
165. Top of dark-grey shaly limestone, 15 feet 5 inches.
150. Do. reddish-grey with some shale, 8 feet.
Grey shale, 2 feet.
140. Top of buff, earthy, hard (hydraulic) limestone, 8 feet.
132. Top of grey shaly rock, 7 feet.
125. Top of buff geodiferous limestone, 5 feet 6 inches.
120. Top of dark-grey shale, 21 feet.
99. Top of black slate, 39 feet.
59. Solid bed of buff earthy limestone, 1 foot.
50. Earthy fragmentary thin calcareous rock, 2 feet.
48. Green (hydraulic?) limestone, 3 feet.
45. Buff shaly limestone, (top of.)
36. Bed of variegated hydraulic limestone, 1 foot 4 inches.
25. Bottom of brownish-grey shale rock, 11 feet.
Concretionary limestone with calcareous spar.
0. Blue limestone in bed of Butler's fork of Crider's creek.

The cliffs on the Cumberland river are composed nearly of the same material as the above section, with some seventy to eighty feet of blue limestone in addition, beneath the zero of that section.

The arch through the "Rock House," which affords a direct passage for Miller's creek to empty into the Cumberland river, is excavated in the blue limestone. This is a remarkable feature in the landscape on the edge of Russell and Cumberland counties. The roof of this arch is fifty feet above the bed of Miller's creek. About one hundred feet of blue limestone are exposed on the Cumberland river, near the Rock House, and forty to fifty feet above is the bottom of the black shale.

In the range of the red clay land, some ore has been found, on the table land near the road leading from Creelsboro' to Jamestown, which was worked at a furnace that was in operation some twenty-five years since, but with what success I am not informed. The ore is probably associated with the chert overlying the upper beds of shaly limestone.

Half a mile above the mouth of the Caney fork of Wolf creek, borings have been made for salt water, and a weak brine obtained.

CUMBERLAND COUNTY.

At Burksville the lower strata are mostly concealed in the extensive bottom lands adjoining the Cumberland river; but the black slate is seen in the adjacent hills, at an elevation of 164 feet, as exhibited in the following section:

320. Top of ridge north of Burksville.
270. Grey shaly limestone.
255. Do.
240. Grey shale, associated with beds of encrinital limestone.
190. Top of thick bed of limestone.
Grey shale and encrinital limestone.
1[illegible]5. Top of black slate 26 feet thick.
159. Bottom of do.
Hydraulic and earthy limestone.
0. Blue limestone, low water of the Cumberland river.

Though the thickness of the stratum of blue limestone was not well seen here, there appears to be about one hundred feet of its upper part exposed at other places in the valley of the Cumberland river, in this county.

On Crocus, the blue limestone dips 2° to the northeast; a short distance up Puncheon Camp, the slate dips at an angle of about 1° in a course south 20° west, while not far off, on the creek, it dips with about the same angle, in a course north 10° to 20° east. Hence it is evident that the dip is very irregular.

Commencing on the top of Puncheon Camp hill, the following section was obtained, down to the black slate:

250. Summit level.
230. Buff, compact limestone one foot.
Dark grey shaly limestone.
200. Encrinital limestone, alternating with calcareous shale.
190. Top of dark grey calcareous shale.
175. Top of buff encrinital limestone.
170. Top of compact red grey limestone 1 foot 6 inches.
160. Top of bed of geodiferous limestone, two beds each one foot thick.
Dark grey shale.
125. Bed of compact grey limestone intercalated in the dark grey shale.
100. Very dark grey shaly limestone.
98. Dark do.
75. Dark grey shaly limestone.

Calcareous shale.

60. Red grey shaly limestone.

54. Bottom of shaly limestone.

50. Ash colored schistose calcareous shale.

30 to 20. Thick rugged encrinital limestone.

10. Ash colored shaly rock.

0. Top of black slate in bed of Puncheon Camp creek.

Assuming the height of the top of the black slate here at one hundred and ninety feet above the Cumberland river, as at Burksville, then the total height of this ridge, above the same point, will be four hundred and forty feet. The mass of calcareous rocks above the black slate, is at least one hundred and seventy-five feet, and the rocks of Upper Silurian and Devonian date below the black slate, are from forty to fifty feet in thickness.

Crocus creek is quite falsely represented on existing maps of this county. It runs much nearer to the Cumberland river than laid down, and heads in Russell county, not far from Walton Coffee's farm.

On Crocus, borings for salt were put down one hundred and fifty feet; also, on Salt Lick, and between two hundred and three hundred feet on Black Fish; on Marrowbone, about five hundred feet, and two hundred feet on Little Rennox creek; some salt water was obtained, but not in sufficient quantity to justify the expense. At the latter locality, on Rennox creek, mineral oil, or petroleum, rose to the surface with the saline water, after boring one hundred and fifty to one hundred and sixty feet, and accumulated in sufficient quantity to make it a profitable article of trade. When I was there, in the summer of 1855, the quantity was but small. Thousands of dollars worth of this oil are said to have been taken to market from this spring, in former times, and sold at the rate of sixty dollars per gross, pint bottles.

In the extreme southwestern part of Cumberland county, adjoining the Tennessee line, the black slate is only about eighteen feet in thickness; over this are twenty-eight feet of grey shales, including three beds of chert, surmounted with four feet of encrinital limestone, which will make a good building stone; over this is two feet of shaly limestone, and ten inches geodiferous limestone.

The black slate rises rapidly in a N. E. direction, on Kettle river—as much as thirty to forty feet in a few hundred yards—under it are seen:

81. Bottom of black slate.
    Layer of chert.
    Mudstone.
79. Earthy silicious spirifer limestone.
70. Hard grey spirifer limestone.
62. Bottom of ledges of spirifer limestone.
    Rocks concealed.
15. Heavy ledges of lynx beds of the blue limestone of Lower Silurian date in place.
0. Bed of Kettle river.

The hard grey spirifer limestone, noted at seventy feet in the preceding section, is probably of Lower Silurian date. If so, it lies within eleven or twelve feet of the bottom of the black slate, and the whole rocks referable to the Devonian and Upper Silurian period, under the black slate, are here, near the Tennessee line, thinned away so as to be hardly recognizable.

MONROE COUNTY.

The dividing ridge between Big Barren and Sulphur Lick, is about six hundred feet above the Cumberland river. This ridge contains an immense mass of grey and green shales, overlying the black slate in the bed of the latter stream. The black slate is here about twenty-five feet thick, while the overlying shales seem to be some two hundred and seventy feet thick. At the junction of these two groups there are some rugged layers of cherty and silico-calcareous rocks, two and a half feet in thickness.

Over the grey and green shales there is some soft yellow mudstone and fossiliferous limestone, containing *Spirifer cuspidatus*, and some other sub-carboniferous fossils, while the summits are crowned with the *Stylina* or *Lithostrotion* chert, mixed with red clay, overlying alternating beds of limestone and shaly limestone, about one hundred and twenty-five feet in thickness.

By uniting the various sections obtained in this county the succession may be approximately represented thus:

600. Summit level, soil and earthy materials.
570. Red clay and Lithostrotion chert.
550. Shaly rocks.
545. Harder layers of do.
525. Hard grey limestone.
     Red ferruginous (calcareous) clay.

510. Grey shaly rock.
Red ferruginous (calcareous?) clay.
470. Yellow schistose calcareous rock.
460. Schistose grey calcareous rock.
454. Hard beds of grey limestone.
450. Do. with geodes.
Dark and light grey shales, forty feet thick.
410. Thin bedded encrinital limestone.
Place of coarse-grained sandstone.
400. Place of Spirifer cuspidatus limestone?
Mudstone.
390. Continuation of grey and green shales.
325. Ferruginous mudstone.
310. Bed of limestone interstratified in the shale.
270. Intercalated limestone in the shale.
132. Bottom of grey and green shales.
130. Impure cherty and silicious layers.
129. Top of black slate.
110. Bottom of do.
Hydraulic limestone? (greenish-grey.)
Grey and green silicious limestone with some chert nodules.
Earthy limestones.
104. Thick bedded limestone.
95. Schistose, decomposing thin bedded limestone.
85. Grey, schistose, earthy limestone.
75. Decomposing hydraulic limestone.
70. Greenish-grey banded hydraulic magnesian limestone.
Space with blue limestone concealed in the debris and alluvium of the Cumberland river.
0. Water of the Cumberland river at the Turkey Neck Bend.

There is, therefore, in Monroe county, an immense mass of shaly rocks, which appear to be almost wanting in Cumberland and Russell counties.

The principal axis of disturbance, already made mention of, which passes in a southwest course through Lincoln, Casey, Russell, and Cumberland, into Monroe county, probably crosses the Cumberland at the Riffle near the Turkey Neck Bend, where a dip of about 4° was observed at the head of the Riffle, in a direction south 50° east, while a reversed dip north 50° west, at about the same angle, was noticed near the foot of the Riffle.

It appears, therefore, that with the exception, perhaps, of a short interval of interruption by the aforementioned table-land of Russell

county, a nearly continuous narrow zone of blue limestone, of Lower Silurian date, can be traced through these counties, nearly connecting the wide spread area of this formation in central Kentucky and Ohio on the north, with the "central blue limestone basin of Tennessee" on the south.

The neck of connection, near the boundary line of Kentucky and Tennessee, passes through the valley of the Cumberland river, as high as Russell county.

From the base of Crider's Hill, in Russell county, these lower rocks seem, so far as we have yet examined, to be concealed from view by the superincumbent strata, until they re-appear again near Liberty, in Casey county.

Imperfect veins of sulphurets of zinc and lead traverse the limestone under the black slate, in the bed of Sulphur Lick creek, in a direction south 20° west.

On the Anderson branch of Sulphur Lick the black Lingula shale is twenty-five feet in thickness; it is covered by a pyritiferous calcareous band of four inches, over which is a layer of chert of two feet five inches. On the great mass of green and grey shales reposes the first bench of limestone observed here.

ROCKCASTLE COUNTY.

The sub-carboniferous limestone may be said to be the foundation of the county, though there are small areas adjacent to Rockcastle river, Roundstone, Crooked, and Horselick creeks, where this formation has a capping of millstone grit.

Though there are upwards of one hundred feet of the sub-carboniferous limestone exposed, on the southeast side of Rockcastle river, where the London and Mt. Vernon road crossed, but forty feet of this formation can be seen on the northwest side, overlaid by a soft incoherent conglomerate.

Five miles southeast from Mt. Vernon, a considerable thickness of dark-grey carbonaceous sandstone is exposed, which has all the appearance of the salt bearing rock of Clay county.

On a spring branch that flows into Skegg's creek, one hundred and twenty-five feet of sub-carboniferous limestone is exposed.

The southerly dip of the rocks and northerly rise, bring a dark

shale, near the top of the sub-carboniferous limestone, upwards of three hundred feet up in the country, two miles from Mt. Vernon.

There is said to be some good coal on Roundstone, and on the waters of Skegg's creek, but I have not yet had an opportunity of examining the localities.

The beds of sub-carboniferous limestone with *Lithostrotion* chert, reach the surface a short distance west of Mt. Vernon, underlaid by greenish-grey marly beds. On the adjacent hill-sides are numerous geodes, containing chalcedonic quartz.

I have not yet been able to ascertain whether beds of iron ore, of sufficient extent to be profitably worked, occur in Rockcastle county, over the sub-carboniferous limestone, as in Powell county, but there are considerable surface indications of ore in the eastern and southern parts of the county.

WARREN COUNTY, CONTINUED.

The limestones of the sub-carboniferous group, which underlie the farming regions of this part of the county, are very analogous to those of the northern part of Trigg, in the vicinity of Wallonia. The subsoil is quite red, and lies shallow, within easy reach of the sub-soil plow, or even the ordinary plow.

In the vicinity of Bowlinggreen a rocky terrace of beds of the subcarboniferous limestone, of about one hundred feet in thickness, rises above the level of the town. It is composed of;

Rough weathering limestones at top;

White limestones in the middle;

Compact dark grey limestones at the base.

From the top of this terrace there is a commanding view of the valley of Green river, the stream flowing through a fine body of land, resting on the sub-carboniferous limestone, bounded on the north by a distant range of millstone grit and conglomerate, from two hundred to two hundred and fifty feet above the valley. The rocks between Bowlinggreen and the Blue Lick Sulphur Spring generally lie near the surface.

Under the red clay, which forms the substratum of the higher grounds, there is a bed of light-colored argillaceous marl, from six to seven feet thick, reposing on ledges of limestone beneath, and loose blocks of limestone strewed on the slopes above.

Two miles from Jenning's creek the rocks are mostly grey and light colored limestones, both compact and semi-crystalline, containing silicious geodes. Under these is a white earthy hydraulic-looking limestone.

On Salt Lick creek the pentremital limestone is in place, fifteen to twenty feet above the bed of the branch, of a light grey color and semi-crystalline aspect. These strata, by a barometrical measurement, are about three hundred feet above Gasper river.

Associated with the pentremites is *Zaphrentes centrales?* and small *Terebratulæ*. The penetremital limestone forms the base of the ridge on the west side of Gasper river, the upper section of which is millstone grit. This ridge continues on to the Butler line.

MORGAN COUNTY, CONTINUED.

Valuable tracts of coal lands exist in the northern part of this county, explored this summer. The best sections exposed, of these Coal Measures, are on Caney, a branch of the main Licking river, entering from the south, Mordecai creek, a branch of the Elk fork of the Licking, and the main stream itself.

There appear to be two horizons of cannel coal in this county, lying some two hundred and eighty to three hundred feet a part. The upper of these beds is composed, where it has been fairly opened, at William Cox's place on the south side of the main Licking, of fourteen inches of cannel coal on the top, and fifteen to eighteen inches of bituminous below, with a grey shale parting of eight to ten inches between, making about forty inches in all. At Cox's opening it is situated one hundred and eighty feet above the Licking river. The lower main cannel coal was not seen on the Licking river. It probably lies there forty to sixty feet below the Licking, as there appears to be a synclinal axis in the valley of that stream, near West Liberty.

On Mordecai creek, at Mr. Schoolfield's, I had the best opportunity of seeing the face of this bed on the waters of the Elk fork. At the first opening the whole bed measures there thirty-nine to forty inches, of which thirty to thirty-two inches is block cannel coal, the bed being made up as follows:

	Inches.
Sandstone roof.	
Bituminous coal, - - - - - - - - - - - -	5
Coal rash parting, - - - - - - - - - - -	1 to 1½
Solid cuboidal cannel coal, - - - - - - - -	28
Clay parting, - - - - - - - - - - - -	1
Hard grey shale, - - - - - - - - - - -	0.5
Hard cannel coal, - - - - - - - - - - -	3 to 3½
Making in all, - - - - - - - - - - - -	39

At the second opening, higher up, on the same branch, the whole bed measures three feet nine inches, of which thirty-six to thirty-seven inches is good coal. Twenty feet below the top of the cannel coal, in the beds of the main Mordecai creek, there is a fifteen-inch bed of bituminous coal thus:

Sandstone.
20. Main cannel coal.
16. Sandstone and black shale.
1.3. Fifteen inches bituminous coal.
0. Bed of Mordecai creek, on Mr. Schoolfield's land.

This bed also shows itself on a small branch of the Elk fork, above Mr. Dyer's house, on lands owned by Crow, Buckner and others, but a slide having covered the face of the coal at this point, there was no opportunity to measure it. It is, probably, of a corresponding thickness to that on Mordecai creek. The hills on the Elk fork, near these localities, are probably hardly high enough to take in the upper cannel coal. Any hills which are three hundred feet above the main coal may take it in.

The main cannel coal of Morgan county, with a fine cuboidal fracture, is well exposed on the waters of Caney, in the vicinity of Judge Lykens'. In this neighborhood, the Cannel Coal measures from thirty-two to thirty-six inches, and perhaps still thicker on some of the branches of the Stone Coal fork of Caney.

The upper cannel coal, equivalent to William Cox's bed, one hundred and eighty feet above the main Licking is situated here near the top of the hills. This upper bed is more schistose in its fracture than the lower main cannel of Caney. The two beds lie here about two hundred feet apart.

The succession of the Coal Measures of the upper Licking, in Morgan county, as near as I am able to give it, from these preliminary observations, is as follows:

Sandstone, capping the Licking hills;

Shale;

Upper cannel, consisting of fourteen inches of cannel on top; eight to ten inches of clay and shale parting, and fifteen to eighteen of bituminous or shop coal at bottom, in all, three feet three to four inches;

Space of about eighty to ninety feet, filled mostly with shaly rocks; some iron ore and a thin coal about the middle of the space; sandstone equivalent to that over the Hazelrigg coal, forty to fifty feet;

Hazelrigg bituminous coal, consisting of two members, with an eight-inch clay parting, measuring in all three feet;

Space of one hundred and fifty feet, filled mostly with shale and soft sandstone, with a thin coal about one hundred to one hundred and ten feet below the Hazlerigg coal, in the bed of the Licking, near West Liberty;

Main cuboidal cannel coal, of Morgan county, three to four feet;

Sandstone and shale, fifteen to twenty feet in all;

Fifteen to twenty inch bituminious coal;

Sigillaria and calamites sandstone, with lenticular veins of coal; in some places three in number, from two to eighteen inches thick at Benton's mill, forty to fifty in all;

Thin coal and shale under the above sandstone;

Dark shales with carbonate of iron, fifteen to twenty feet in thickness;

Bituminous coal, fifteen to twenty inches in the bed of Caney, half a mile below Burton's mill;

Conglomerate ? below the bed of Caney.

The main lower cannel coal of Morgan county, appears to occupy the same geological horizon as coal D, of Lesley's section, of the Pennsylvania measures, for reasons given in the first chapter; if so, then it is a coal higher in the series than coal C, the great repository of cannel coal of Pennsylvania. The identification of these coals requires, however, a detailed survey to establish their position satisfactorily. The main cannel coal of Caney and Elk Fork, is full of remains of *Stigmaria, impressed completely in the substance af the coal itself*, in an excellent state of preservation, another evidence that this kind of vegetation contributed largely to the formation of cannel coal.

The composition of these coals of the upper Licking, will be seen

by consulting Dr. Peter's report, from Nos. 286 to 297, inclusive, under the head of Morgan county.

A specimen from the Schoolfield bank, investigated for its oily products by Dr. Peter, yielded, from one thousand parts, one hundred and seventy-six parts by weight of crude oil; Breckenridge coal yielding, from the same weight, three hundred and eighteen parts. The volatile combustible matter yields forty-four to forty-five per cent. of the weight of the coal. The ashes six to seven per cent. The ashes seem, however, to be variable in different parts of the bed, since one specimen, No. 686, yielded 21.5 per cent. of ashes.

No specimens have yet been analysed from the waters of Caney.

Above the forks of the Stone Coal branch of main Caney, the stream runs for a long distance over bare ledges of cannel coal, which measures here from thirty to thirty-six inches. On the lower part of the Stone Coal branch, the cannel coal rests on a bluish grey fire clay, which runs into sandstone, higher up on that stream. At some places there is a little bituminous coal under the cannel; but in others, it is all cannel.

In the divide between Caney and Red river, there is some limestone where the barren coal measures set in.

On Grassy, there are some good beds of coal, but these I have not yet been able to explore; one on the Shoal branch, near Hampton's mill, is said to be a good thick bed.

Several salt springs and deer licks occur in Morgan county. There is little doubt but salt water might be obtained by boring in some of the synclinal troughs of these coal measures. A favorable place would probably offer itself in the valley of the Licking, in the vicinity of West Liberty, unless the inclination of the strata is such as to have permitted a drainage of the saline matter in a northwest direction.

A soil was collected for chemical analysis from this county, over the coal measures of the valley of Caney, near Judge Lykens', supporting a growth of white oak, beech, sugar-tree, and black walnut. The original undergrowth was cane, hence the name of this water course.

ADAIR, GREEN, ALLEN AND BARREN COUNTIES.

Nearly the whole of these counties are within the range of the subcarboniferous limestone. The lower members of this formation lying to the southeast, and the middle members to the northwest, capped on

some of the highest points with the upper members. The former are earthy and shaly, and, for the most part, dark colored; the latter, purer limestone, generally lighter colored, and more massive in its beddings.

The succession in the southeast part of Barren county, of the lower group, on Glover's and Skegg's creeks, is:

First: on the tops of the ridges, usually an encrinital cellular chert, resembling buhrstone;

Encrinital and pentremital limestone;

Dark grey semi-crystalline limestone, used in the construction of chimneys;

Yellow earthy soft silicious mudstone;

Ash colored, earthy, and shaly limestone;

Geodiferous earthy limestone.

Encrinital limestone, which shows itself in the beds of this stream, from three hundred and fifty to three hundred and eighty feet below the highest beds here indicated. The strata here occupying the summits, are probably equivalent to the lowest beds in the Barrens, lying to the northwest, and may therefore be regarded as the base of the barren limestone series, or middle members of the sub-carboniferous group.

The soil on the high grounds, over the members above designated, except where it is based on the red clay, seems to have a sour tendency, since there is a great disposition for it to produce sorrel and sourwood, in the old clearings sedgegrass. This land would be very much benefitted by liming.

Where the Columbia road crosses Cabin, Dry Fork, Cedar, and Glenn's fork, the lowest rocks exposed were the shaly and geodiferous limestone of the lower division of the sub-carboniferous group. Between Cedar and Glenn's creeks, the strata are, for the most part, shaly, and the country has a glady aspect. The land derived from these beds is not nearly as productive as that based on the red clays which underlie about one-half of Adair county.

In the bed of Russell creek is a compact grey sub-crystalline limestone and chert, very regularly jointed, one set of joints being south 35° east; another set south 50° to 55° west. This limestone underlies the shaly limestone. The rocks have a dip 6° to 8° to the south

10° west. On Russell and Caney fork, the dip becoming more westerly in the descent of that stream.

The shaley limestones gradually disappears under the cavernous beds of the sub-carboniferous limestone formation near the western borders of Adair county.

The cavernous or barren limestones of the middle division of the sub-carboniferous group are the prevailing rocks of Green county, which are often quite cherty, and characterized by *O. crinistria, T. lamellosa? Spirifer striatus.*

These members of the sub-carboniferous group range in a southwest direction, through the barrens of the northwest part of Barren and Allen counties.

In the valley of Barren river, on the confines of these two counties, the local uplift of the strata brings the black lingula shale to the surface, its entire thickness of fifty feet being exposed a mile above where the Scottville road crosses Barren river, but it sinks rapidly down stream to the northwest, which brings it forty feet below the surface at a point where a boring was put down some years ago for salt, on the banks of Barren river, three quarters of a mile below the bridge.

About one hundred feet of encrinital and shaly limestone, containing concretions, are superimposed on the black Lingula shale.

A few feet of impure grey limestone is seen just at the water's edge, below the black slate, at the point of greatest elevation of the strata. It appears, therefore, that there is no great mass of soft argillaceous shale covering the black slate in Barren and this part of Allen county; the section above the black slate being analogous, lithologically, to those heretofore given in Russell county, and very different, in this respect, from those in Monroe county.

Characteristic soils of the more productive portion of the Barren limestone region, based on red clay sub-soil, were collected from Mr. Barlow's farm, and near the noted locality, of the "Big Sink." The result of the analysis of one of these varieties will be seen by consulting Dr. Peter's report, Nos. 225 and 227, pages 136 and 137 of the second volume of Geological Report. This soil may be taken as a type of the best soil derived from that member of the sub-carboniferous group, characterized especially by the Lithostrotion of the Barrens, formerly known under the name of *Stylina*, which prevails through

that district of the sub-carboniferous limestone, originally an open country of grass and hazel bushes, destitute of timber, now grown up, to a great extent, with the barren oak. (*Quercus Catesbœi.*) This soil is well adapted for small grain and corn, and brings also a good quality of tobacco.

In Green county the red ferruginous soil, overlying the Barren limestone formation, in the vicinity of Greensburg, is elevated from two hundred and forty to two hundred and seventy feet above Green river, as shown in the following partial section obtained:

270. Farming land over the red ferruginous sub-soil mixed with chert.
210. Bed of compact limestone, three to five feet thick.
205. Schistose limestone, three feet.
201. Bed of compact limestone, one to two feet.
Soft marly rock.
189. Bottom of do., twelve feet thick.
Sub-crystalline limestones.
170. Bottom of do., externally of a brownish-red color.
135. Marly limestones and
Top of Spirifer limestone.
Space with rocks, mostly concealed, consisting of light and dark-grey semi-crystalline, marly, cherty and coralline limestones.
0. Green river.

These strata have a westerly dip, in some places, of 3° to 4°. On Little Barren river the direction of the observed dip was north 70° west.

Some iron ore occurs on the waters of Brush creek, near the line between Green and Taylor.

On the confines of Green and Hart counties hydraulic limestone is interstratified, in the sub-carboniferous group, near Williamson's blacksmith shop, four miles from the turnpike, and eleven miles east of Munfordsville.

HART COUNTY.

With the exception of a small tract of land on the headwaters of Roundstone, and, perhaps, a still smaller area on Bacon creek, the whole of this county is based on the sub-carboniferous limestone.

At an elevation of about two hundred and sixty to two hundred and seventy feet above Green river, near the base of the knobs, south of that stream, the oolitic beds of the sub-carboniferous limestone are in place; but the prevailing members that underlie the principal farming

districts of the country are the cavernous beds of this formation, the upper beds of which contain *Syringopora* (*ramulosa?*)

Four miles north of Munfordsville, the conglomerate shows itself, increasing in quantity towards Bacon creek. In the elevated country towards the mouth of Roundstone creek, and perhaps also on Bacon creek, there are some beds of coal, but their extent and thickness have not yet been ascertained; it is doubtful, however, whether they are of workable thickness.

Amongst the many subterranean streams of Hart county, the "Blue-hole" must be, from the accounts of the citizens, (for I have not yet had an opportunity of examining it in person,) one of the most curious and remarkable, from its immense depth, the fine fish which it affords, and the singular periodical fluctuations to which its waters are said to be subject. It is supposed to have some connection with Green river, from which stream, during high stages, the water rushes with such violence, as to overpower and paralyze the fishes swept in by the velocity of the current. This singular locality is situated three or four miles from Munfordsville, and not far from Green river.

TAYLOR AND LARUE COUNTIES.

All the high table lands of these counties are based on the sub-carboniferous limestone. To the northeast, on the slope, descending to the waters of Salt river, the sections expose the sub-carboniferous freestone, ash colored shale, and black slate.

The section obtained, on Muldrow's Hill, in Larue, will give, perhaps, the best idea of the section of the strata in this part of the state:

420. Terminus of turnpike.*
415. Solid limestone.
410. Marly shale, with limestone.
375. Ash colored shale alternating.
360. Dark shales.
350. Thick bedded bluish grey limestone.
345. Buff soft shale.
342. Thick bedded limestone.
Cherty limestone.
330. Thin and thick bedded limestone.
315. Limestone decomposing.
310. Solid beds of limestone.
305. Schistose limestone.

*The highest points of Muldrow's Hill, are from ninety to one hundred feet higher.

300. Hard solid limestone in beds from six to eighteen inches.
290. Bluish grey earthy calcareous rock.
285. Thick-bedded limestone.
265. Base of do., and top of knob freestone, with intercalations of shale.
140. Base of do., and top of ash colored shales.
65. Black slate.
25. Base of do.
25. Top of encrinital limestone.
20. Magnesian limestone.
0. Bed of Rolling Fork of Salt river, at New Haven.

These thicknesses are subject to a slight correction, for southwesterly dip into the hill side, where the measurement was taken; but the various divisions of the sub-carboniferous formation of Muldrow's Hill, in Larue county, will not vary much from—

Upper calcareous division, one hundred and fifty feet;

Middle silicious division, one hundred and twenty feet;

Lower argillaceous division, seventy-five feet.

The exact line of junction between the lower argillaceous division and the black slate, was not satisfactorily seen in this section; but, taking the thickness of the black slate at forty feet, which is probably nearly correct, it will make the ash colored shale seventy-five feet in thickness.

Three sub-carboniferous soils were collected in these counties, two of which are very distinct in their character and composition. The one collected in Taylor county, from the oak lands, one mile southwest of Allen Garret's Horse Mill, near the Bradsfordsville and Campbellsville road, where large over-cup oaks grow, that frequently attain a diameter of three feet, is remarkable for its light color and fine—almost impalpable—texture. This land supports, besides the large over-cup oak, several other varieties of timber—the red, scarlet, barren, black-jack and chincapin oaks; with mock-nut hickory and dog wood; under-growth, sassafrass, shumach, hazel-nut, and some huckleberry. This soil becomes, by cultivation, of a very fine texture, and has a mealy appearance in dry seasons. It is tolerably good tobacco land, yields from thirty-five to fifty bushels of corn, and ten bushels of wheat to the acre. This soil is derived, chiefly, from the ash-colored shales and washings from the knob freestone. It is like some of the quaternary soils of southwestern Kentucky, and from the striking resemblance to these I have been led to suspect that a large portion of

the fine marly quaternary loams must have been mainly derived from the debris of this geological formation, together, perhaps, with the fine shales of the Coal Measures.

Another variety of soil was collected in Taylor county, three and a half to four miles northwest of Campbellsville, in the black and red oak lands, where there are loose blocks of cellular chert overlying beds of limestone shale. The red and white oaks grow, on this soil, to very large dimensions. In old clearings a dense growth of small white poplars, briars, persimmons, scrub-oak, and shumach, very soon come up, spontaneously; there is so great a disposition in the soil to produce shrubbery of this kind that it becomes a great annoyance to the farmer.

The third variety was collected in Larue county, on a farm two miles from Hodgenville, then occupied by Daniel Keunedy, over the beds of sub-carboniferous limestone and associate stylina chert, where the growth is black and white oak, mock-nut, and pignut hickory, with an undergrowth of dog wood, persimmons, sassafrass, and shumach. This land has a tendency to come up in sassafrass, shumack, briars, and blackberrys. The soil has not as red a color as is frequently the case amongst the stylina chert beds of sub-carboniferous limestone, and is much paler than it is one mile west of this locality, on the other side of the South fork of the Big South fork of Nolin creek. This soil is better adapted for wheat than corn, yielding, on an average, fifteen bushels of wheat.

The best soil of Larue county lies between Middle and Nolin creek.

The base of the sub-carboniferous limestone, at its junction with the knob freestone, on the east branch of Pitman creek, consists of alternations of encrinital with brownish and ash-colored shale, chert, and limestone shale. There is a bed of solid limestone both below and above this shale.

On the comb of the main range of Muldrow's Hill, north of Pitman creek, quantities of white and other quartzose pebbles are strewed on the surface, apparently the debris of the remnant of an outlier of the conglomerate and millstone grit, at the base of the Coal Measures, which, at one time, capped this hill, where, in consequence perhaps of some local subsidence of the strata, it appears in a situation where it would otherwise not be expected.

At the Lick Gap, in the northeast corner of Taylor county, the black slate is surmounted by the ash-colored shale. On Tallow or Block House creek there is a complete labyrinth of knobs, where the arable land is confined almost entirely to the slopes and contracted flats along the course of that stream. The soil, for the most part is of a similar character to that collected near Allen Garret's Horse Mill. The ash-colored shale is surmounted in places with mudstone and chert.

CHRISTIAN, TODD, LOGAN, AND SIMPSON COUNTIES.

The Coal Measures of the northern part of Christian county have been described both in the report of the Topographical Assistant, and also in the 1st vol. of the Geological Report, page 126.

The middle and southern part of this county and Todd, and the whole of Logan and Simpson counties, are based on the sub-carboniferous limestone, and chiefly on the cavernous beds of that limestone group. The southern parts of these counties present a very fine level agricultural district.

The chemical analyses of some soils from this portion of the sub-carboniferous limestone of Kentucky, have been completed, and will be seen by consulting No. 20, page 272, of the First Report; the sub-soil, from the same locality, being No. 216, on page 147, of the Second Vol. of this Report. No. 161 page 355, of First Report; the sub-soil from the same locality being No. 480, page 260, of the Second Vol. of this Report; No. 62 and 63 of the First Report, page 356 and 357; No. 141, page 342, of the First Report; the sub-soil from the same locality is No. 217, page 244, of the Second Vol. of Report.

Nearly opposite the "Mineral Spring," on Mr. Lindsey's property, a bed of hydraulic limestone is interstratified in the sub-carboniferous group of Christian county, beneath which a fine spring issues.

There are numerous extensive caves in the southern part of Christian, and many subterranean water courses which issue occasionally, in bold streams, sufficient to turn a large mill; one of the most noted of these is Dr. Quarles' "Big Spring," not far from the Tennessee line. Near the Davis station, by John Bell's, there are several extensive caves, which have been excavated and weathered out of the cherty and earthy limestone of the sub-carboniferous group. In the early settlement of the country James Daviess lived for some time in one of these caves, which has much the appearance of having been once the channel of a subter-

ranean stream: its entrance opens towards Cave creek, which flows near by. Nearly the whole of the southern part of these counties has been prairie, except the belts of timber along the water courses. It would appear that the soil has been peculiarly adapted for grasses, and was originally clothed with a most luxuriant growth of "barren grass," nearly as high as a man on horseback. After the settlement of the country this grass died out, and timber, chiefly black oak, hickory, and hazel bushes, took its place, where the fires were kept out.

Reticulated corals, allied to *Gorgonia infundibuliformis*, are the most abundant fossil in the sub-carboniferous limestone, near the line of Christian and Todd.

A copious spring issues from the cavernous limestone, near the Chimney cave. This forms one of the principal sources of Red river.

Near Trenton, in Todd county, the limestone has an oolitic structure, some beds of which might afford a good cream-colored marble; other beds are semi-crystalline, and contain a *Productus* allied to the *Cora*, remains of *Phillipsia* and *Terebratulæ*.

Deep and sub-soil plowing is found very beneficial in the soil of this part of Kentucky. No. 136, on page 357 of the 1st volume, will be found the analysis of the soil collected two miles from the Elk fork of Red river, in the oak timber. The sub-soil is yellow or reddish-yellow. With the exception of occasional depressions over "sink-holes" this country is level, and well adapted for farming.

On the Elk fork the beds of the sub-carboniferous limestone are ledges of sonorous bluish-grey close textured limestone, with some segregations of black flint (chert.)

In the adjacent ravines the under-clay is quite red, and contains *Lithostrotion* (*Stylina,*) *basaltiforme*, *Syringopora*, and a *Bellerophon*, which has been referred to the *hiulcus*, but which is, probably, a distinct species.

There are three tolerably good layers of building stone in the dark-grey close textured limestone on the west side of the Elk fork of Red river, almost free from cherty concretions, which are very numerous in the layers near the waters edge above the bridge. On the left bank of this stream, a section of about sixty-five feet of rock is exposed, where the origin of chert is very plainly seen in the form of nearly spherical and mammillary segregations, projecting from the surface of the ledges. The strata dip at an angle of about 3° north northeast.

Some of the rock has the texture of lithographic limestone, but are not sufficiently uniform, as far as they can be seen, to be valuable for that purpose.

A quarter of a mile above Hollingsworth's mill a fine spring issues from a cavernous fissure in the limestone, about five yards from the Elk fork, and runs underground into that stream.

A fine farming country of the same description extends from the Elk fork to Keysburg, based on the same formation, with occasional sinkholes.

Between Keysburg and Whippoorwill creek there are occasional exposures of sub-carboniferous limestone and Lithostrotion chert. The country, however, is not so level as west of the Elk fork.

The limestone which has been used in the foundation of the bridge over Whippoorwill creek is full of *Productus punctatus*. The same kind of country extends to Little Whippoorwill and Spring creeks. On the former stream low ledges of dark-grey cherty limestones are visible. The soil is based on red under-clays. This country is better suited for clover and timothy than for blue-grass. The sedge-grass has a great disposition to come up spontaneously on this land, and is considered by the farmers generally to have an injurious influence on the ground, except in so far as it prevents the land from washing.

The beds of the sub-carboniferous limestone, which show themselves nearest the surface, in the central part of Simpson, are schistose dark-grey limestones, with spheroidal cherty segregations, with fine specimens of *Lithostrotion*, (*Stylina*.) In the northern part of this county the sub-soil is redder than in the southern part, and lie shallow, so as to be easily reached by deep ploughing. The growth is chiefly barren oak, with some hickory and walnut.

REMARKS IN CONCLUSION.

Every county in the state has now received a *general* geological examination. The detailed survey has been extended over Union, Hopkins, Greenup, and part of Hancock, a small portion of Crittenden, Christian, Carter, and Lawrence. The base line will, it is hoped, be extended, by the close of this season's field-work, about eighty to one hundred miles from the mouth of Highland creek, in a due east course through the state.

If we were in possession of a correct geographical map of the entire state, the geological data now collected would enable me to lay down, with *approximate general* accuracy, the boundaries of the different formations, but not all the meanders of the same, except in the counties which have received a special geologico-topographical survey.

To complete the outline of the western coal field it is now only necessary to connect the surveys on the confines of Hopkins and Muhlenburg with those made this season in Hancock, through Muhlenburg, Ohio, parts of Butler, Edmonson, Grayson, and Breckinridge counties. This might be accomplished in the course of two years more, with sufficient force.

To complete the outline of the eastern coal field, from the surveys on the edge of Greenup and Carter, to the Tennessee line, through Carter, Morgan, the edge of Bath, Montgomery, Estill, Owsley, Madison, Rockcastle, Laurel, Pulaski, Wayne, and Clinton, would require a longer period, because the distance and area is greater, and the country much more difficult to survey.

To accomplish this work in the shortest time, I would recommend that there be one Topographical Assistant employed exclusively on the western coal-field, and another on the eastern coal-field, so as to avoid the loss of time and the expenditure required for one man to travel to and from the distant portions of the State, and because, by this arrangement, each Topographical Assistant could head personally his respective corps, and the assistant of each could then carry the levels with the theodolite, simultaneously with the compass lines, which, by the previous arrangement, has only been very partially accomplished. For the want of accurate levels on the out-crops of the different coal beds, it has sometimes been impossible to make up a correct opinion in regard to the dip of the measures, and the consequent topographical proof of the identity of coal beds; an investigation, which now, in the present progress of the survey, has become one of the most important, interesting, and essential features of the geological survey, in connection with the palaeontological evidence of the equivalency of the different beds now assuming a form, in western geology, not only of the highest import to Kentucky, but also in all other states where coal regions exist; and that not only as a matter of scientific investigation, but a subject having perhaps, as important a practical bearing as any connected with the science of Geology.

In the further prosecution of the Geological survey, there is no doubt that the first and most important work to be done, is the further extension of the lines defining, topographically, the precise boundaries of her two coal-fields, and surveying, simultaneously, the beds of coal and iron ore lying adjacent to those lines. Next in order, should come the filling up of the topographical work still lacking in the interior of the coal-fields. This would comprise, in the western coal-field, the whole of the counties of Henderson and Daviess, and the portions of Ohio, Muhlenburg, and Grayson, lying within the marginal survey. In the eastern coal-field, Breathitt, Floyd, Pike, Letcher, Perry, Harlan, Clay, Knox, Whitley, and the parts of Carter, Morgan, Owsley, Laurel, and Pulaski, which might lie within the marginal survey. After that would come the survey along the boundary lines between the formations belonging to the sub-carboniferous, Devonian, Upper, Lower Silurian, extending through the counties of Lewis, Fleming, Bath, Montgomery, Estill, Madison, Garrard, Lincoln, Casey, Russell, Cumberland, Taylor, Marion, Larue, Nelson, Bullitt and Jefferson. These are the counties which require especially to be topographically surveyed, in order to be able to construct a reliable geological map of Kentucky, one of the great ulterior objects of the survey.

The base line is now carried entirely across the western coal field, affording now, not only a basis of departure for all surveys to start from, in Henderson and Daviess counties; but the means, also, of closing and connecting any surveys already commenced, or which may be undertaken in the western coal field.

A short time will suffice to carry that line into the eastern coal field, where it can be taken up by the eastern corps and carried across that field, for the attainment of the same objects in that district of the State.

In the two hundred and two soils, sub-soils and under-clays collected from different geological formations, which have already undergone a chemical analysis, and are reported in this and the two preceding volumes, Kentucky has already undoubtedly done more towards obtaining a just knowledge of her agricultural resources, than any State in the Union. There remains, however, much to be done, even in this department of the survey, as there are between forty and fifty counties from which either the analyses cannot be completed in time for this report, or from which soils have yet to be collected and placed in the hands of the chemist. Further, in many of the counties from which

soils have been collected, and the chemical analyses reported, there are often several other varieties of soils that should be selected and analysed, in order to give a complete insight into the Agricultural character of the county.

Besides the soils now on hand, ready for the labors of the chemist, there are from sixty to one hundred specimens of orês, coals, limestones, marls, &c., that still remain in the chemical department of the survey at Lexington, besides probably as many more recently collected, and not yet placed in the chemist's hands.

In the Paleontological department of the survey, including the very important investigations connected with the identification of coals by the organic remains in their shaly roofs, only a commencement has yet been made. My own timé has been so fully occupied in field and general office work that I have been able, as yet, to devote but very little time to the specific determinations of the many new species of organic remains which have been collected. Before they can be labeled, classified, and placed in the state cabinet, these specimens must receive a thorough paleontological investigation. Ten plates of important and interesting genera and species will appear, and be described in this volume; of these, the fossil plants have been studied and described by M. Leo Lesquereux; the crinoidea by Sidney S. Lyon, and the Coal Measure molusca by Edward T. Cox. The two latter gentlemen I have aided occasionally with counsel and opinion, where doubt and difficulties have arisen; but otherwise my duties have not permitted me to share in their descriptions.

The correspondence of the Geological Survey of Kentucky, which I have had personally to attend to, has already become a business which encroaches largely on my other duties.

To render the Geological Survey of Kentucky a complete and generally useful work, all that has been above enumerated must be done. It will then be in a condition, when the country becomes older, richer, and the forest is cleared away, to be connected with an extended trigonometrical survey, which all the states of the union will undoubtedly ultimately receive, upon a plan somewhat similar to the ordinance survey of England, a work, which, in the present condition of the country, is impracticable, without an outlay beyond the means of its present population.

D. D. OWEN,
State Geologist.

THIRD CHEMICAL REPORT

OF THE

SOILS, MARLS, ORES, ROCKS, COALS,

MINERAL WATERS, &c.,

OF KENTUCKY,

BY

ROBERT PETER, M. D.,

CHEMICAL ASSISTANT TO THE GEOLOGICAL SURVEY.

INTRODUCTORY LETTER.

CHEMICAL LABORATORY OF THE GEOLOGICAL SURVEY,
Lexington, Ky. September 14, 1857.

D. D. OWEN, M. D:

Dear Sir:—In obedience to your instructions, I herewith transmit to your address, my report of the Chemical Work, done in this Laboratory, since the preparation of the second volume.

As you will perceive, the time employed has been mainly occupied with the analyses of soils and sub-soils, which have generally been collected by you in series of three or four from each locality; including the *virgin soil, soil from an old cultivated field, sub-soil from the old field, and sometimes the under-clay and underlying rock stratum*, so as, if possible, to exhibit, by means of the Chemical Analyses, the changes which may have been produced in the various soils by cultivation, and the removal of agricultural products, without the application of manure, as well as the character of the immediate sub-soil, under-clay, and subjacent rock strata, and the probable influence they may exert upon the superficial soil.

With very few exceptions, as you will perceive on the perusal of the accompanying report, the analyses demonstrate, in regard to these, as to the soils previously examined, a notable change attributable to the cultivation of the soil; more especially a diminution of the quantity of those mineral elements which are necessary to vegetable growth, and which have been mainly removed from it in the various agricultural products which have been carried from the soil. The analyses reported in the accompanying report, may be summed up as follows:

138 Soils, sub-soils, and under clays.
16 Limestones.
12 Limonite iron ores.
7 Carbonate of iron ores.
12 Coals.
9 Mineral waters.

6 Sandstones.
5 Shales.
6 Marls.
3 Clays.
2 Iron furnace slags.
2 Pig irons.
2 Efflorescence and mineral Chætetes.

220 in all.

There remain, however, in my possession, a large number of interesting specimens, of your recent collections, consisting of between fifty and a hundred soils, &c., and more than an equal number of iron ores, coals, limestones, (hydraulic and common,) marls, &c. &c., which will be examined early next year, should the next General Assembly make the necessary appropriations for the continuance of the Geological Survey.

All of which is respectfully submitted.

ROBERT PETER.

INTRODUCTORY REMARKS.

SOIL ANALYSIS.

The processes pursued in the analyses of the soils, during the progress of this Geological Survey, have not been previously detailed, because it was thought that it might prove tedious and uninteresting to the general reader; but, with a view to enable those who are qualified, by chemical studies, to judge of the accuracy of the methods of research, by which the results detailed in this and the preceding reports were obtained, it is thought advisable now to record the routine of the operations. The general reader will, at least, be able to form an opinion of the time, care, and labor necessary to make a good and useful analysis of a soil.

Preliminary operations.—The soil to be analyzed, after it was brought to the laboratory, was allowed to remain, in the cotton bag in which it was first collected, fully exposed to the warm free air of the room, until it had been thoroughly dried at the common temperature. It was then passed through a wire seive of about one hundred and fifty apertures to the inch, and, if in clods, rubbed to powder in a mortar, with precaution not to grind up any of the gravel or fragments of rock, &c., which it might contain; which were thus removed and estimated. The object of this operation is to bring the whole specimen of soil to a state of uniform mixture, and to remove from it the coarser gravel, vegetable roots, &c, which it might contain.

Digestion in water charged with carbonic acid.—For this process, by which we hope to estimate the proportion of *soluble matter* in the soil, *which is immediately available for vegetable nourishment*, a quantity, generally thirty grammes, of the air-dried soil, is weighed and placed in an eight-ounce strong vial, with a close fitting stopper, and the bottle is filled up with distilled water, which has been charged with pure carbonic acid gas, under a pressure of about two atmospheres. The closely stopped bottle, properly numbered, is then allowed to remain, for about a month, in a sand-bath, so placed, in relation to the fire, that the temperature is generally about that of summer heat. After

this time the contents are filtered, and the clear liquid evaporated carefully to dryness, in a glass beaker, finishing the evaporation at the temperature of boiling water, in a platinum capsule. After this dried extract has been cooled under a bell-glass, over sulphuric acid, it is carefully weighed, and its proportion of *organic and volatile matters* estimated by the loss which the dried extract sustains after these matters had been completely burnt off at a red heat over the spirit-lamp. The fixed residuum of the extract, after burning off the organic and volatile matters, was next dissolved in pure hydrochloric acid, with a little nitric acid added to per-oxidate the iron, if necessary; the solution filtered, and the undissolved *silica*, after drying and ignition, was weighed. But, of most of the soils treated in this way, the *fixed residuum* was black or very dark colored, from the presence of a large proportion of per-oxide of manganese, and consequently, when it was dissolved in hydrochloric acid, a considerable amount of chlorine gas is evolved, in mixture with the carbonic acid, which results from the dissolution of the carbonates present. From which fact it is evident that, in most soils, especially those which are rich in organic matters, the oxide of manganese exists in a condition to be easily soluble in water charged with carbonic acid.

The acid solution of the *fixed residuum* was now analyzed in the usual way, as will be described under the *general analysis*. It not being thought advisable, in the analysis of this extract, however, to spend the time which would be necessary to estimate separately the alumina, oxide of iron, oxide of manganese, and phosphoric acid, which are contained in the precipitate produced by the addition of ammonia to the solution, as these various ingredients are more completely estimated in the *general analysis* of the soil—the object of the digestion of the soil in water charged with carbonic acid being, as above stated, mainly to ascertain the relative proportion of easily soluble matter present in it, which would probably represent the quantity of *immediate available* food for plants which it contained.

It is to be observed, however, that as the carbonates of lime, magnesia, and manganese, as well as some forms of the organic matter of the soil, are quite soluble in the carbonated water, the *extract* may be in comparatively large quantity, if these substances are in considerable proportion in the soil, whilst there may be a relative deficiency of potash and soda, or of phosphoric and sulphuric acids; so that, conse-

quently, the actual weight of the *soluble matter*, extracted by the water charged with carbonic acid, will not exactly represent the present fertility of the soil. The analysis of this extract, however, it is believed, is carried far enough to enable us to judge of these relationships.

Estimation of the fine and coarse sand.—The thirty grammes of soil which have been digested in the water charged with carbonic acid, whilst still wet, is washed out of the filter into a glass cylinder, in which, in the course of several days, the *sand* which it contains is washed as clean as possible from the clay and finer particles of the soil: this is done by mixing it thoroughly with water, allowing it to stand until the sand has subsided, then pouring off the turbid water, and repeating this operation until the sand and coarser particles, generally, settle perfectly clear. The sand, &c., are now poured on a filter, dried at 212° F., and weighed; it is then sifted through a seive of fine bolting cloth, of five thousand apertures to the inch, and the coarser particles weighed, and examined with the aid of the microscope.

It is to be understood, however, that although, in all the soils examined, very fine silicious sand exists in large proportion, all that is washed out in the operation just described is not of this character; for, in many of the soils—especially those from the central limestone districts of the state—there is a considerable quantity of rounded, soft, ferruginous mineral, resembling concretions, generally small, called by some "shot iron ore," or larger, called "iron gravel," which add their weight to that of the silicious sand washed out by the water. These ferruginous particles dissolve, mainly, in the acids in which the soil is digested for analysis; and thus it sometimes appears that the sand, &c., washed out of the soil by water may be more in weight than the *sand and insoluble silicates* found in the general analysis.

The coarser particles of some other of the soils, especially those from the Quaternary Formation, Coal Measures, or sub-carboniferous sandstone, are frequently silicious sand; and sometimes the microscope discloses in it rounded grains of quartzose minerals, of various kinds, similar in appearance to those of the boulders of the drift period.

GENERAL ANALYSIS.

The general analysis of the soil is usually completed long before the processes just detailed are brought to a conclusion. The quantity

of soil taken for this purpose is generally two grammes. This quantity, introduced into a weighed platinum crucible, is exposed to the temperature of 400° F., in an oil-bath, for three or four hours, and weighed after it has again been allowed to cool down to the ordinary temperature under a bell-glass over sulphuric acid. The loss of weight which it experiences is the weight of the *moisture*, generally called *Hygrometric moisture;* the quantity of which generally exemplifies the absorptive power of the soil—in other words, the relative amount of water which it is capable of holding, at the ordinary temperature, when it is apparently perfectly dry. The *aluminous* soils hold more of this *moisture* than the *sandy;* and those which contain a large proportion of *organic matters* hold the most of any; the *organic matters*, called *Humus, Geine*, &c., &c., by writers, having a higher hygrometric power than almost any common substances known. This same quantity of soil in which the moisture has been estimated is now ignited in the crucible, over the spirit-lamp, with free exposure to the air, until all the *organic and volatile matters* are burnt off and dissipated. Weighed with the same precautions the loss of weight gives that of these substances, which consist of black or brownish organic matter, (humus, geine, &c., &c.,) water, with traces of ammonia and nitric acid.

This same portion of the soil is now transferred into a small beaker glass, and digested for about ten days, at a moderate temperature, in strong nitric acid, to which a little hydrochloric acid has been added, for the estimation of the phosphoric acid of the soil, by the process of Sonnenschein. For this purpose, at the end of this time, the mixture is filtered, and a sufficient amount of molybdate of ammonia is added to the filtrate,* which is then evaporated nearly, but not quite, to dryness, on the sand-bath. During the evaporation, the excess of nitric acid, with the aid of the chlorine from the hydrochloric acid, decomposes all the ammonia of the molybdate of ammonia, and the molybdic acid goes down, with all the phosphoric acid present, as a precipitate, insoluble in water and in pure nitric acid. After diluting with pure water the concentrated acid residuum, and allowing it to stand for some hours to settle and cool thoroughly, the precipitate, containing the phosphoric and molybdic acids, is collected in a filter and washed with cold distilled water; all the other materials of the soil, soluble in

*The term *filtrate* is applied to the clear liquid which passes through the filter.

diluted nitric acid or water, pass through the filter. This moist precipitate is now dissolved out from the beaker and the filter, by means of water of ammonia, and from the solution the ammonio-sulphate of magnesia precipitates all the *phosphoric acid*, as ammonio-phosphate of magnesia; which, after standing for about twelve hours, is collected in a filter, washed thoroughly with diluted water of ammonia, dried, ignited, and weighed, and the phosphoric acid estimated—its proportion to the soil, dried at 400° F., being obtained by calculation. When, as sometimes occurs, a considerable excess of molybdic acid has been thrown down with the phosphoric acid, the addition to the ammoniacal solution of an excess of chloride of ammonium is necessary, to prevent some of it from falling with the ammonio-phosphate of magnesia, and causing an error of excess in the estimation of the phosphoric acid; but, when conducted with the precautions indicated, this method, which is a slight modification of the process of Sonnenschein, is found to be far superior, in rapidity, accuracy, and delicacy, as a general process applicable to most complex mixtures, to any other hitherto used for the estimation of phosphoric acid; and, more especially, its use will greatly increase the certainty and utility of analyses of the soil, in which it has hitherto been a matter of great difficulty accurately to estimate this essential ingredient.

The filtrate from the mixed precipitate of molybdic and phosphoric acids, not being further employed in the analysis, another quantity of two grammes of the same soil, which has been sufficiently dried at the temperature of 400° F., is digested for about ten days, at a moderate temperature, in the sand-bath, in a hard glass flask, with an excess of pure hydrochloric acid, to which a little pure nitric acid has been added—the mixture being allowed to boil for a few minutes at the end of the process. After dilution with water the mixture is then filtered, and the *sand and insoluble silicates*, washed, dried, and ignited, are now accurately weighed and recorded.

The filtered solution is immediately precipitated with pure water of ammonia,* and the precipitate, (which consists of alumina, oxides of iron and manganese, phosphates, and generally some magnesia,) after

*In some of the early analysis this acid filtrate was first evaporated to full dryness, and redissolved in diluted hydrochloric acid, to estimate the *soluble silica*, but this additional process was soon abandoned, because it was believed the time necessary for it could be more profitably employed in increasing the number of the comparative analyses.

being well washed with hot water is transferred, while yet moist, into a silver crucible, in which it is digested for some hours in the water-bath, in pretty strong solution of absolutely pure potash; which dissolves out the alumina from the other ingredients, (except some of the phosphoric acid which is disregarded in this process.) The potash solution, filtered from the remaining oxides of iron and manganese and the magnesia, is now acidulated with hydrochloric acid, some chlorate of potash being added to destroy any organic matter which might interfere with the full precipitation of the alumina, and, after the solution has been concentrated to a small volume by evaporation, the *alumina* is thrown down from it by an excess of ammonia and some sulphuret of ammonium; it is washed very carefully with hot water, dried, ignited, and weighed. The mixed oxides of iron and manganese, and the magnesia, remaining from digestion in the potash solution, are now dissolved from the filter in hydrochloric acid, the solution carefully neutralized with ammonia, and the oxide of iron precipitated by the addition of succinate of ammonia, which throws it down as basic succinate of iron, leaving, if the process is carefully performed, all the oxide of manganese and the magnesia in the solution. On filtering the mixture, to separate the succinate of iron, after it has been somewhat washed from the filtrate, some ammonia is added to the precipitate in the filter, which, by withdrawing from it the succinic acid, facilitates the subsequent process of ignition preparatory to weighing the *oxide of iron.*

The *oxide of manganese* is now precipitated from the filtrate, after it has been concentrated by evaporation to a small bulk, by the addition of sulphuret of ammonium, and from the concentrated filtrate, any magnesia which may be present, is thrown down and estimated as triple phosphate, by the use of phosphate of soda and ammonia. It is recommended by Rose, to re-dissolve in hydrochloric acid, the sulphuret of manganese, (precipitated by sulphuret of ammonium,) and re-precipitated it with carbonate of soda, &c.; but it was found by experiment, that thorough roasting of the sulphuret of manganese, converted it easily into the brown oxide, and this complication of the process wac thus avoided.

Returning to the first filtrate from the precipitate, by the addition of ammonia, to the original acid solution, which contains all the lime, most of the magnesia, some oxide of manganese, the sulphuric acid, and the alkalies;—simultaneous with the operations which have just

been described, we throw down the lime, from this filtrate, by the adtion to it of oxalate of ammonia; collect the precipitate on a filter, dry, ignite it, treat it with solution of carbonate of ammonia, and weigh it; the *lime* is thus estimated as *carbonate of lime,* in the usual way. To the filtrate from the oxalate of lime, which now contains a large quantity of ammonia salts is next added an excess of *perfectly pure* nitric acid, and it is evaporated to complete dryness, on the sandbath. In this process, proposed by Prof. J. Lawrence Smith, the nitric acid destroys all the ammonia salt, and leaves the magnesia, oxide of managanese, and alkalies, as nitrates, with any sulphuric acid which may have been in the soil, provided a heat sufficient to dissipate that acid has not been used at the latter end of the operation. It sometimes happens, however, where there is a considerable quantity of free ammonia, or of oxalate of ammonia, in the liquid, that some of the ammonia is left as nitrate of ammonia, which is more difficult to decompose than the hydrochlorate in an excess of nitric acid; and which, if left in the residuum, would interfere with the subsequent processes. To remove this, it is only necessary to add a new portion of nitric acid with a little pure hydrochloric acid, which, by the evolution of chlorine, soon destroys the ammonia which is present.

The dried residuum of nitrates, &c., is now removed from the sandbath, allowed to cool, and drenched with *pure* acetic acid, and a sufficint quantity of distilled water, and enough of pure acetate of baryta is added to the dilute solution to precipitate all the sulphuric acid; after the precipitate of sulphate of baryta has subsided, it is collected by filtration, washed, dried, ignited, and weighed, and thus the *sulphuric acid* of the soil is estimated.

The filtrate from the sulphate of baryta is now evaporated to dryness, and transferred, by means of a little oxalic acid and water, into a small porcelain capsule, in which it is heated and evaporated again to dryness with an excess of pure oxalic acid, which changes the nitrates into oxalates. The dried residuum, which contains the magnesia, some oxide of manganese, and the alkalies, is next perfectly ignited, which changes the oxalates to carbonates, any excess of baryta from the acetate being also changed to carbonate.

To separate the *alkalies* from the other ingredients of this residuum, it is thoroughly washed with water through a filter, and the dissolved alkaline carbonates changed to chlorides by the addition of a little hy-

drochloric acid; the saline residuum, after complete evaporation and ignition of this solution in a platinum or porcelain crucible, is weighed and the weight of the *alkaline chlorides* is recorded. Re-dissolving this mixture of chlorides of potassium and sodium, in water, the two alkalies are separated and estimated in the usual way, by evaporation of the solution in a water-bath with chloride of platinum, washing the soda-chloro-platinate from the potash salt, which, collected on a weighed filter, and dried at 212°, is weighed, and thus the *potash* and *soda* are estimated.

The *magnesia*, which remains in the portion of the residuum which is insoluble in water, is now dissolved on the filter in diluted sulphuric acid, and after evaporation of the solution, and ignition in a platinum capsule, it is weighed as sulphate. Should there be much *oxide of manganese* in the insoluble residuum, the magnesia is dissolved out of the mixture by means of diluted nitric acid, (sulphuric acid being subsequently added to the filtrate &c., to convert it to sulphate,) and the oxide of manganese separately estimated.

By this mode of analysis, it will be seen, that with the exception of the moisture, organic matters, and phosphoric acid, which are estimated in a separate quantity of the soil, all its ingredients are determined from a single weighed portion, and thus a useful control over the general accuracy of analysis is secured; for if the sum of all the ingredients found, varies much from the weight of the quantity of soil taken for analysis, it is a proof that some error exists, and the processes must be repeated.

Other constituent ingredients of soils might have been estimated in these analyses, as for example, *chlorine*, *nitric acid*, *or nitrates*, and especially *ammonia*; but whilst it is known that these, or some of them, are almost constantly present in soils, their determination would have required separate processes, and would have increased the time and labor necessary for the analysis, probably more than would have been justified by the value of the results, diminishing in a proportionate degree the number of different soils which could be submitted to examination in the limited time. This is especially the case with ammonia, which, according to recent experiments in the laboratory of Liebig and elsewhere, is *always present*, in considerable proportion, in all soils, even the most sterile. The reader will readily admit that time and

labor enough are required to complete the analysis of a soil, even without the separate estimation of these ingredients.

The same remarks would apply to the seperate determination, in the analysis of the soils, of the *various kinds* of organic matters which is present in them, by means of various alkaline solutions, &c., &c. It has been usual to attach much importance to the separation and estimation of the different varieties of these substances found in soils; but it is believed that these determinations, which consume a great deal of time, are of comparatively little practical value, as it is known that these varieties of organic matters of the soil pass readily into each other, and that doubts even exist as to the separate identity of some of these *humic acids*. Moreover, experience and chemical analyses demonstrate, that the fertility of a soil is far from being in proportion to the quantity of organic matters present in it.

With a view to reduce the expenditure of time and labor to as small a limit as possible, and hence to increase, to the greatest extent, the amount of work done in the laboratory in a given time, the writer has, during the course of these investigations, carried on a great number of separate analyses at the same time, taking care to ticket each digestion flask, beaker, funnel, capsule, &c., with a number and letter corresponding with those attached to the record of the operation in the Laboratory note-book—in which every single process performed is recorded at the instant, under its proper head—he generally has had as many as twenty to forty different soils in the course of analysis at once, in various stages of progress; and three times that number of operations—as drying, digestion, precipitation, filtration, washing, evaporation, weighing, &c.—progressing at the same time, so that the oil-bath, sand-bath, and water-bath; the range of filter stands, twelve in number, are sometimes all crowded at once; and the operator, having every instant of his time in active and profitable use, never has occasion to wait a moment on any of the operations, which, by the use of a little forethought, follow each other in a constant succession, without injury to any, or confusion.

In this manner, by the most careful attention to the numbers on the beakers, filters, &c., &c., and the continual and careful record of every operation at the time of its performance, and of every product or educt as it is obtained and weighed, error and confusion may be avoided; and with the final summing up of the analysis a demonstration of

its accuracy is generally obtained. In fact the influence of any unconscious bias of the mind, in relation to any soil under analysis, is thus prevented, as it is not generally known, except by reference to the record book, to what soil the substance in hand belongs, which is designated on the beaker, filter, funnel, &c., by its key number only. In this mode of working, also, many of the mechical operations, as those of trituration, filtration, washing precipitates or the sand, &c., &c., have been performed by an intelligent young assistant, and thus the amount of effective work has been doubled, for the time being, without a corresponding increase of expense to the state; and, consequently, a larger number of minute analyses have been completed in the time employed than would be thought possible by many experienced analytical chemists, some of whom are persuaded that no more than one analysis of this kind—classed amongst the most difficult—can be carried on at one time.

As already stated, it is believed by many persons, and even some chemists of experience, that the art of chemical analysis has not arrived at that degree of certainty and accuracy, that the changes produced in the soil by cultivation can be ascertained by this means, even with the aid of the purest reagents and the most delicate balances. This opinion is strengthened by the memorable failure of the experienced German chemists, who were employed by the *Landes Oeconomie Collegium*, (board of agriculture,) of Prussia, to endeavor to ascertain the changes produced in soil on which a single kind of crop had been cultivated until it refused to bear it any longer. To make the determination more accurate each sample of the soil so treated, by different farmers, from fourteen parts of the kingdom, were entrusted to three different chemists to be analyzed; and the results obtained were so very discrepant as to be entirely useless, as may be inferred, from the inspection of the following table, giving a view of the proportional quantities, in round numbers, of phosphoric acid, of soda, and of potash, in three corresponding analyses, by three different chemists:

From Liebig and Kopp's Jahresbhricht for 1849.

Number of the soil.	Phosphoric acid			Potash			Soda		
	In first analysis.	In 2nd analysis.	In third analysis.	In first analysis.	In 2nd analysis.	In third analysis.	In first analysis.	In 2nd analysis.	In third analysis.
1	1	3	7	3	1	0	6	1	0
2	1	19	92	1	12	6	1	19	67
9	trace	114	1	3	1	2	2	2	1
10	1	103	18	trace	0	0.05	trace	0	0.04

Liebig attributes these great variations to the difficulty of procuring, from a field, a perfectly uniform average specimen of the soil; but we cannot help believing that other causes, such as want of care to secure the utmost degree of accuracy, use of the reagents sold commonly as chemically pure, &c., &c., must have helped to produce the discordant results; we will not, however, pretend to sustain an opinion on this peculiar case, in the face of such high authority, but will be content with the assertion, that, in our laboratory, experience in many such operations, sometimes repeated more than once on the same specimens of soil, has now fully demonstrated, that whilst, in operating with the small quantities, necessarily taken in a soil analysis, to learn the composition of the millions of tons of soil of a whole district of country, and especially the changes produced in it by cultivation, it is necessary to use every precaution, and the utmost degree of delicacy and accuracy in all the operations; yet, that with the means and appliances *now* at the service of the analytical chemist, such a result is attainable; and we think this statement, however hazardous it may seem, will be found to be sustained in the following report.

It is agreed, however, that it could not be attained before the balance of the analytical chemist had been brought to its present degree of delicacy; it could not be done before the discovery of some of the improved modern processes of analysis—for example, those for the easy and certain determination of the phosphoric acid and the alkalies. It cannot yet be done without constant attention to every precaution, and the utmost watchfulness against error in every operation. Some of the necessary precautions it may be well enough briefly to enumerate:

1. All the acids and other reagents, and the distilled water, used in the processes, must be *absolutely and perfectly pure;* and, as *perfectly pure* reagents are somewhat rare, even amongst those which are sold by

manufacturing chemists as *chemically pure*, it is always necessary full y to test, as to their purity, all the substances employed, and, very frequently, to purify them. It has been necessary, for example, during the course of these investigations, to purify, by re-distillation, all the nitric acid, hydrochloric acid, and sulphuric acid used, notwithstanding they had been purchased from chemical manufacturing houses, with the express stipulation that they should be supplied perfectly *chemically pure*. The oxalic acid, oxalate of ammonia, acetic acid, other reagents supplied were also almost always to be purified, to secure accuracy in the results.

2. The best Swedish filter-paper, purified first by digestion in diluted hydrochloric acid, and thorough subsequent washing, for some hours, by displacement, with distilled water, must be employed.

3. The digestion flasks and beakers, in which the soil is submitted to the action of acids, must be of the very *hardest* glass, which is not attacked, in the slightest degree, by hot hydrochloric acid.

4. To secure a fair comparison, in analyzing several specimens from the same locality, in order to ascertain the effects of cultivation upon the soil, or the relative nature of the sub-soil or under-clay, it is necessary to digest each sample in about the same quantity of acid of equal strength, and expose each to the same temperature for the same length of time; because, many of the ingredients of the soil—even potash and soda, and especially alumina, oxide of iron, lime and magnesia, and perhaps phosphoric acid—are in combination with the silica, as silicates, which are acted on with difficulty, even by concentrated acids; it is found that the stronger the acids, the greater the relative quantity of them employed, the longer the time of the digestion, and the higher the temperature, the more of *these insoluble silicates* are decomposed, and the more of the above mentioned ingredients, and the less of insoluble residue, are found in the analysis.

We take occasion here, incidentally, to remark, that the quantities of the essential ingredients of the soil—of the potash, soda, lime, magnesia, phosphoric acid, &c.—which are stated in the following analyses, do not *fully* represent the total of those contained in the soil analyzed, because of the fact that some of these substances still remain locked up, for the present, in the *insoluble silicates*, which resisted the action of the acids as applied, but which can only become available for the

uses of growing plants, after a slow decomposition of those silicates, under the atmospheric agencies, during a great lapse of time.

5. In the estimation of the potash, by evaporation, in the water-bath, of the solution of the mixed alkaline chlorides with chloride of platinum, the capsule containing the mixture must be entirely secluded from the ammoniacal fumes which are frequently floating in the air of the laboratory, for the obvious reason that as these fumes are greedily absorbed by the mixture, the additional weight of the ammonia—chloride of platinum—thus produced, would increase the apparent weight of the potash found, and thus cause a serious irregularity.

6. The use of the most delicate and perfect balances, the most careful attention to accuracy in weighing, to the weights, and counterpoise, and to the most scrupulous cleanliness of every vessel or article used in the processes.

In addition to all, may be mentioned, the necessity for a good deal of preliminary training in chemical manipulations in the laboratory, without which it would be useless to attempt such delicate operations with any hope of success. The idea proposed by some, that a farmer might be able to analyze his own soil, is founded on an erroneous view of the nature and objects of a good soil analysis.

If it were true, as was believed by even some distinguished chemists, not very long ago, that the value of the soil, and its influence upon crops, depended mainly on its *mechanical or physical properties*, it might be easy, by a series of careful siftings and washings with water—such as were proposed by persons having this idea of soil analysis—for a farmer to perform these operations for himself, with the aid of very simple apparatus But since it has been discovered—as will be seen to be demonstrated also by the analyses of Kentucky soil—that, although much depends upon the physical properties of a soil—as on its relative degree of fineness, or coarseness, &c.,—yet the real source of its ability to support vegetable growth is mainly in its *chemical constitution;* and that the *difference between a fertile and a sterile soil,* both frequently having nearly the same *physical properties, is caused by the difference in their proportion of those essential ingredients which generally exist in the soil in the smallest quantities*—quantities, which, when compared with the whole weight of the soil, may seem to be very insignificant, and which, in such a portion as is generally ta-

ken for a soil analysis, could often not be appreciated by means of a *common balance*.

This fact may be seen to be exemplified in the two following analyses taken from the preceding volume of this report. The one of soil No. 226, from the knob formation in Russell county, and the other of soil No. 550, virgin soil, from the blue limestone of Lower Silurian formation in Woodford county—rich "blue-grass" soil—which may be taken as extreme cases:

	No. 226	No. 550
Soluble extract given up, by 1000 grains of the soil, to water charged with carbonic acid,	2.221	6.014
Organic and volatile matters,	4.170	7.771
Alumina, and oxides of iron and manganese,	4.478	12.961
Carbonate of lime,	.176	2.464
Magnesia,	.066	.173
Phosphoric acid,	.088	.319
Sulphuric acid,	.227	.150
Potash,	.063	.394
Soda,	.068	.130
Sand and insoluble silicates,	90.786	75.266

The difference in the productiveness of these two soils does not depend on their mechanical or physical properties, as is proved by the fact that they are both in an equally fine state of division and are perhaps equally well drained, &c. It does not depend on their relative proportions of organic matters, or of alumina and oxides of iron and manganese, for it is found that soils may be comparatively unfertile, although they may contain large proportions of these; but it depends upon the greater relative amount of lime, magnesia, phosphoric acid, potash, and soda, contained in the blue limestone soil.

Of these important substances, the difference in quantity, in the two soils, may seem insignificant at first sight, or to the experienced observer—as for instance, in the case of the phosphoric acid, only the difference between 0.088 and 0.319 of a part in a hundred parts of the soil; or, in the case of the potash, only the difference between 0.063 and 0.394 of a part in the same quantity; yet they will be found to be relatively quite large, on comparing together the various soil analyses in the following report, and swell to something enormous when we apply these proportions to the whole quantity of soil in an acre of ground. Thus, the whole of the phosphoric acid in soil No. 226,

on the acre of ground, estimated to weigh about three millions of pounds, (3,000,000 pounds,) taken to the depth of one foot, is two thousand six hundred and forty pounds, (2,640 pounds); that in soil No. 550, in the same space, is equal to nine thousand five hundred and seventy pounds (9,570 pounds;) and whilst the potash on the acre of soil No. 226, to the depth of one foot, is only equal to one thousand eight hundred and ninety pounds, (1,890 pounds,) that in soil No. 550 amounts to eleven thousand eight hundred and twenty pounds, (11,820 pounds,) to the acre.

Taking the relative amounts of *soluble matters*, given up by one thousand grains of each of these two soils, to water charged with carbonic acid, No. 220 gave 2.221 grains, or a little more than two grains; No. 550 gave 6.014 grains, more than six grains. Or, one pound of the former soil gave up only 15.547 grains, a little more than fifteen and a half grains—whilst a pound of the latter yielded more than forty-two grains, (42,098 grs.); the former in the proportion of six thousand six hundred and sixty-three pounds (6,663 lbs.) to the acre, to the depth of one foot, and the latter in that of eighteen thousand and forty-two pounds, (18,042 lbs.) to the acre, of soluble matters immediately available for vegetable nourishment.

The great importance, now generally acknowledged, of these, mineral elements of the soil which usually exist in it in small proportions, has only been recently established, and by means of numerous analyses of soils and vegetables, and especially of their mineral elements, as exhibited in their ashes, accompanied by many experiments in agriculture and horticulture, and on the growth of vegetables generally.

Even the great Berzelius, the best analytical chemist of the beginning of the present century, seems not to have fully appreciated the paramount value of these, nor the real objects of a soil analysis; and the equally celebrated Sir Humphrey Davy, exhibits an equal want of this appreciation in the analyses of soils published by him. Let us, for example, glance at two soil analyses by these distinguished men quoted by Liebig in his Chemistry applied to Agriculture, &c., and see how much of the real value and properties of the soils can be learnt from them:

"*Surface-soil of a field which produces the most abundant crops, and has never been manured, (Berzelius,) one hundred parts, consist of—*

Silicious sand,	57.900
Silica,	14.500
Alumina,	2.000
Phosphates of lime and iron,	6.000
Carbonate of lime,	11.000
Carbonate of magnesia,	1.000
Insoluble extractive matter,	1.250
Insoluble extractive matter, destructible by heat,	4.000
Animal matter,	1.600
Resin,	.250
Loss,	.400
	100.000

"This great chemist has strangely omitted to detect in this soil, "potash, soda, chlorine, sulphuric acid, and manganese. As this soil "is eminent for its fertility, there cannot be a doubt that all these in- "gredients must have existed in it."—*Liebig.*

"*Surface-soil of a very fertile sandy field, from the vicinity of Tunbridge, Kent. According to Davy, one hundred parts consisted of—*

Loose stones and gravel,	13.250
Sand and silica,	50.250
Alumina,	3.250
Peroxide of iron,	1.250
Carbonate of lime,	4.750
Carbonate of magnesia,	.750
Common salts and extractive matter,	.750
Gypsum,	.500
Matter destructible by heat,	3.750
Vegetable fibre,	3.500
Water,	5.000
Loss,	5.000
	100.000

"The great Davy, who was convinced of the importance of the in- "organic constituents of soils, has omitted to detect phosporic acid, "potash, soda and manganese. All of these must have been present "in the soil, for we are informed that it produced good hops, for which "these ingredients are indispensable."—*Liebig.*

Even as late as the time of the great New York State Survey, the distinguished chemist to that work, Dr. Emmons, of Albany, while fully appreciating the great value of the phosphoric acid, and the alka-

lies of the soils, and claiming to have demonstrated the presence of the former in many rocks and soils, where previously they were not known to exist, fails to give the determination of these valuable ingredients in almost all the numerous soil analyses published in his splendid volumes. And so has it been in most of the publications of this kind in this country and in England, so that almost the whole record of soil analyses is nearly useless to scientific agriculture, except some of Sprengel and others, in Germany and France—such as are quoted in the supplementary chapter on soils, of Liebig's "*Chemistry in its application to Agriculture and Physiology.*"

As late as 1838, in Germany, where the industrious Carl Sprengel had been for many years urging on the attention of the scientific and agricultural world, through his publications, the true *mineral* theory of vegetable nourishment, we find in Schubler's Agricultural Chemistry, published in that year, the opinion gravely supported, that the earthy and saline matters which are found in all plants, and are necessary to their constitution, are actually produced by them, by their growth, out of the common elements of the atmosphere and of water; and the reader is asked, by him, "how can it happen that crops can be produced for twenty to a hundred years, the ashes of which contain large quantities of phosphate of lime and of certain alkaline salts, of which not a trace could be found in the soil on which they grew!" And the author adds—" When Hermbstadt, out of 2,261 pounds of "ashes of the Mugwort, (Artemesia vulgaris,) which grew on 18,000 "square feet of sandy soil, obtained 936 pounds of calcined potash, it "was evident that each cubic foot of this sandy earth must have con-"tained 340 grains of potash, in order that the Mugwort could have "obtained it from that source; as this is not to be believed, in regard "to this Berlin sandy soil, so it is necessary to ascribe the production "of this potash in the Mugwort *only to the luxuriant growth of the* "*plant itself.*"

But Sprengel, by carefully analyzing the soil, proved that within the range of the roots of the mugwort there was greatly more than the requisite quantity of potash. So has it been found in regard to every element which enters into the vegetable or animal composition; the idea that any of them can be *made*, or even obtained by transmutation from other elements, by the force of vitality, is fully exploded by accurate investigation, by means of the balance.

The Mineral Theory of Vegetable Nourishment.—The importance of what has been termed the mineral elements of vegetable food consists principally in the fact, that whilst all those elements of organized beings which exist in the atmosphere and in water, such as carbon, hydrogen, oxygen, and nitrogen, are everywhere abundant, and can never be exhausted, those elements, necessary to the constitution of these beings, which are peculiar to the soil, called by distinction the *mineral elements*, which are contained in the soil in limited quantities, and partially withdrawn from it in every vegetable which grows or animal which feeds on it, may readily be entirely removed from it, and the soil, consequently, rendered sterile.

The credit of this theory, which in latter times has been prominently and eloquently brought forward to public attention by Liebig—if that could be confined to a single individual which has gradually been developed by the labors and writings of many—would more properly belong to Carl Sprengel, a most industrious and accurate agricultural chemist of Germany, who had demonstrated it by his numerous analyses of soils, manures, and vegetables, and published it in his works, long before the time of Liebig's celebrated publications. This last distinguished author, indeed, acknowledges as much in his "*Chemistry applied to Agriculture and Physiology*," in the supplementary chapter on the chemical constituents of soils, where, after quoting some soil analyses from Dr. Sprengel, he adds: "The analyses are those of Dr. " Sprengel, a chemist who has unceasingly occupied himself for the last " twenty years in endeavoring to point out the importance of the inor- " ganic ingredients of a soil for the developement of plants cultivated " upon it. He considers as essential all the inorganic bodies found in the " ashes of plants. Now, although we cannot coincide with him in the " opinion that iron and manganese are indispensable for vegetable life, " (for these bodies are found as excrementitious matter only in the bark, " and never form a constituent of an organ,*) yet we gratefully acknowl- " edge the valuable services which he has rendered to agriculture, by " furnishing a natural explanation of the action of ashes, marl, &c., in " the improvement of a soil. Sprengel has shown that these mineral " manures afford to a soil, alkalies, phosphates, and sulphates—and " further, that they exert a notable influence only on those soils in

*In this statement Liebig is evidently wrong. (P.)

"which they are absent or deficient." The translation and publication, in this country, of some of the works of Sprengel, especially his "*Lehre vom Dunger,*" &c.; would be a valuable addition to the library of the enlightened American farmer.

GENERAL REMARKS ON AGRICULTURE.

The true theory of agriculture, on which only a correct practice can be based, can only be ascertained by accurate observations and experiments, of great number and extent. A few analyses, for example, might only exhibit exceptional cases; the isolated examination of a few soils could be of very little service, for it is only by numerous and comparative analyses that the real causes of fertility or sterility can be discovered. Hence, during the short course of the investigations of modern science, in her efforts to aid this most important of all departments of human industry, agriculture, numerous and fallacious theories, based on imperfect knowledge, have been for a time proposed and maintained, and have in their turn exerted their influence against the steady onward march of real knowledge. A few analyses of the soils of Kentucky, for example, might be of some scientific interest, especially if there had been recorded, minute analyses of known soils of other regions, by which to compare them; but in the absence, or at least paucity, of these, the only mode of ascertaining the various qualities and value of the soils of our state, as well as the relative influence exerted on its fertility by the various constituents of the soil, is by the performance of a great number of analyses, of soils in all variety, from the different geological formations, and in various stages of exhaustion from cultivation. In this manner only can a complete comparison be made between them, and their relative merits and peculiarities exhibited, and, incidentally, the real and essential elements of fertility in the soil fully ascertained, by a process of comparison and exclusion.

In the establishment of a true theory and practice in agriculture, *practical experience and scientific research must go hand in hand.* The one may suggest what the other must necessarily verify. An extensive series of correct scientific investigations, in the chemical analyses of soils, manures, plants and their ashes, &c., &c., must be combined with close practical observations on the culture of various crops, in va-

rious known conditions or circumstances, of soil, manures, moisture, heat, light, &c., &c.

Empirical experience has gone a great way, in the course of ages, towards forming a correct system of agriculture; but its unaided progress is necessarily very slow and uncertain, and confined within circumscribed limits. On the other hand, scientific investigation into the nature of the essential elements of the soil, and the conditions of vegetable growth, can only be verified and established by the aid of practical experience in agriculture.

Practical experience, moreover, looking almost exclusively to immediate results, may be deceived as to the real and ulterior interests of the farmer; for example, the celebrated Jethro Tull, of Berkshire, England, (who published his "*Horse-hoeing Husbandry, and New Method of Culture*, &c.," in middle of the last century,) having observed the beneficial effects of thorough tillage and fine division of the soil, in promoting the growth of plants, came to the conclusion, by his practical experience, that all manures were nuisances which injured the good qualities of the edible plants to which they were applied, and promoted the growth of toads and other "venomous creatures," but that "the artificial Pasture of Plants may be enlarged, without any Addition of more Land, or enlarging of Bounds, and this by Division only of the same Earth." That as the intimate atom is very small, as he expresses it "an atom is nothing," and *fine division* of the soil is the only thing necessary to bring it into a condition to enter into the tissues of vegetables, the food of plants could be increased, in a given quantity of earth, "*ad infinitum*," simply by sub-dividing or pulverizing it, and thus a perennial fertility be secured. Science not having yet demonstrated to him that *earth* was not a unit in composition, of which any small part, if sufficiently finely divided, would answer for vegetable nourishment, it required some lapse of time to demonstrate to his followers the gradual but certain deterioration of the soil thus treated, and the fallacy of his system of husbandry.

In like manner, the practical experience of the early farmers of a new country, where the land is teeming with all the elements of fertility, and which, for years, shows no diminution of its productiveness, even with the rudest agriculture, impressed them with the fallacious belief that the *soil is inexhaustible;* and, consequently, the accumulations of enriching materials—the piles of manures about their barns

and stables—were considered nuisances, to be abated at the cost of the expense and labor of hauling them to the nearest stream or sink-hole, whilst exhausting crops were carried from the soil; until the further experience of fifty or a hundred years has given the melancholy demonstration that the land had, in some cases, become hopelessly deteriorated, and that those valuable elements, which alone were wanting to restore and keep it in a fertile state, had been scattered to the winds, or had found their way to that great reservoir of the drainage of the land, the ocean.

For this great practical error, on the part of our forefathers, there was this sufficient apology, however, that scientific agriculture had not yet demonstrated the true nature of vegetable food, nor the essential elements of the soil. But now the case is different, and any farmer, who is not lamentably deficient in the preliminary education which is necessary to fit him for his station, as an agriculturist and a good citizen of a republican nation, can avail himself, with little difficulty, of the aid of the scientific principles of modern agriculture. And nothing but the great abundance and cheapness of new land in this country, prevents the necessity for acquiring and applying these principles continually to the cultivation of our soil.

As long as rich new soil can be purchased for less than it would cost to restore to fertility a soil which has become exhausted, by a long series of improvident cropping, *practical experience* will continually prompt the farmer to emigrate from the home of his fathers to play the part of a pioneer in the new country, at whatever cost of feeling in the breaking up of old attachments and old associations, at whatever risk to health or life from change of climate and location, and at whatever final expense of time and money, which may be required, gradually, in the course of many years, to bring around the new settlement all the comforts and conveniences which have been temporarily undervalued in the old.

Every road laid out, graded, and turnpiked; every bridge, fence, or house constructed; every railroad, telegraph, or public means of conveyance established; every school-house, college, church, or court-house erected—all the improvements and conveniences of the old country—have been made at the cost of some sacrifice of time, labor, and money of the land owners, in the course of years; and could the real and practical value of all these improvements, comforts, and conven-

iences be put upon the cost of the land, in the old and highly cultivated community, its price would appear extraordinarily high. Could the final cost of all those improvements, which would be necessary to bring the wild new country up to the level in these respects, with the older settlements, be put upon the new land, the difference in price between this and that of the older country would not be so great as it appears at present. But these improvements are gradually made and paid for, and their cost is distributed amongst a succession of persons, and over a considerable time, and consequently is not proportionately felt. But the *value* of a real *improvement* remains, and constantly enhances the value of the land in which it is placed, by increasing the comforts or decreasing the labors of the inhabitants; increasing the value of their products, by giving more ready access to market; diminishing the cost of articles of consumptiou of foreign production by decreasing that of their procurement and transportion; giving new facilities for the profitable employment of time, energy, talent, and capital, in the arts and manufactures; and a more extensive scope for profitable industry in all the departments of civilized society.

Taking all these facts into consideration, it may be more frequently found, than is generally believed, that even *practical experience* may safely admit, that notwithstanding the comparatively high price of the comparatively worn-out soil of the older and improved districts, as compared with the land of the new, it may often be more economical to improve the old, by the judicious restoration to it of its lost elements of fertility, by the application to it of the appropriate manures, than to break up and remove to the new country.

To the farmer who understands the conditions of fertility; the chemical nature of the soil, and of the crops or animals produced upon it; who has studied—as is his duty, as a part of his useful profession—the nature of manures, and the true mode of maintaining his soil always in its original state of fertility, the annual labor of restoring to the soil as much of the essential elements as had been taken away by the crops removed from it, would be comparatively little, if systematically provided for in his scheme of husbandry; whilst to renovate a soil which had been annually robbed, by a succession of owners, for fifty or a hundred years, may seem a herculean labor, and require a startling expenditure.

ROTATION OF CROPS.

It is a very prevalent idea, based on the practical experience, that after the land has become *tired*, as it were, of one crop, it will readily produce another; that a judicious *rotation of crops* may be continued for any length of time, without exhaustion of the soil. This opinion, scientific research has fully demonstrated to be erroneous. It is true, that different vegetables, whilst they require nearly the same elements for their food, consume the several materials of the soil in various proportions—as corn, wheat, and the grains generally, take more *phosphates;* potatoes, tobacco, and the green crops, more *potash;* hemp, clover, and fruit-trees, require *lime* in the soil; and flax is said to demand much *magnesia*, &c., &c.—it is equally true, that the uninterrupted cultivation of one crop on the same land, disproportionately deprives its soluble portion of the peculiar elements which enter in larger quantities into its peculiar composition, and hence reduces the productiveness of the soil to that crop, whilst it may yet retain abundance of the essential mineral elements of vegetable food in such proportions as may be entirely adapted to the wants of other vegetables; but it must be recollected, that although *this* crop may require a larger amount of the phosphates, and *that* more of the alkalies, the third more lime, or the fourth more sulphates, they all take more or less from the stock of these materials in the soil, which, although mostly present there in quantities to last for centuries, are yet limited in amount, and exhaustible in the end.

Thus, whilst during the life-time of the father, perhaps, by a judicious rotation of crops, the productive powers of the soil may seem to be fully or nearly maintained, during the subsequent experience of the son, it may be necessary to resort to sub-soil ploughing to keep up the productiveness to the profitable standard; and yet, notwithstanding the use of this means, further lapse of time may still demonstrate a gradual diminution of crops, in consequence of the gradual, although slow, exhaustion of the soil.

INFLUENCE OF THE SUB-STRATUM.

In districts where the soil is immediately underlaid by a sub-stratum which is rich in the mineral elements of vegetable food, like the easily decomposible blue limestone of the Lower Silurian Formation, or the rich under-clay which abounds in the same region, the process of

exhaustion of the surface-soil is more slow than when it is based upon a hard rock which resists the decomposing influence of the atmospheric agencies, or a stratum in which these elements are more or less wanting. For, whilst the vegetable roots of the growing crops are absorbing these elements from the superficial soil, more are being carried into it, by the agency of water and of capillary attraction, from the rich sub-stratum. This process of supply, however, is often necessarily slow, and rarely keeps pace with the demands of continued exhaustive crops. It is one main cause of the rapid renovation of the soil, in the favored region above mentioned, upon allowing it to rest in fallow or in clover crops.

INFLUENCE OF PASTURAGE.

Another prevalent opinion, also, to some extent erroneous, is, that when the land is used for pasture only, or where the products, in grass, corn, grain, hay, &c., are annually consumed upon the ground by animals—as hogs, cattle, horses, mules, &c., which are the only exports from the farm—the manure being thus restored to the soil, it is in no danger of becoming exhausted. The fact is, that this system of farming really removes from the land less than any other which can be adopted, where some products of the farm must be sold away from it, and no manure is imported to it, because all of the valuable elements of the soil which are finally removed from it, in this system of farming, are simply the phosphates of lime and magnesia, and the other earthy and alkaline salts, which are contained in the bones, and the solids and fluids of the animals reared on it—some idea of the quantity of which may be formed by weighing the skeletons of these animals—whilst, as the constant tendency of growing vegetables is to collect and bring up the essential elements, from the depths of the soil and leave them, by their decay, upon the surface, it may even frequently happen, that notwithstanding the removal from it of this relatively small quantity of phosphates, &c. in the bones and bodies of the animals sold from the farm, the *surface-soil* may be actually richer, after many years judicious treatment in this way, than it was at first.

But in the older countries, where by a long series of cropping, almost all the essential elements of the soil have been so far reduced in quantity that the mandate, "no manure, no crops," is rigid and immutable, the effects of even the grazing of pasture land is known

and understood, especially as we are informed by Johnston, (in his *Lectures on Agricultural Chemistry and Geology*,") in the dairy district of Cheshire, where the application of bone-dust to permanent pasture has been practiced of late years with great success, in improving the value of the pasture land, which had become measurably exhausted of its phosphates by the milk, cheese, calves, &c., sold from it; it being stated by that author that "for every cow it maintains a dairy farm will lose, (annually,) of earthy phosphates, upon the whole as much as is contained in fifty-six pounds of bone-dust." On the principle of the exhaustion of the phosphates from the grass lands of Cheshire, by dairy farming, he accounts for "the singularly striking effects produced by bone-dust" on these lands, "while it failed materially to improve those of others on which it had been tried."

USE OF LIME AS A MANURE.

The analyses of the limestones of the Lower Silurian formation, as well as those from other geological districts, published in these several reports, demonstrate a fact which has generally been over-looked in the efforts made to explain fully the beneficial action of the application of lime upon the soil. It is true that lime itself is generally present in very small proportion, even in soil resting immediately upon a limestone sub-stratum—the common idea of the wide prevalence of *calcareous soils*, being erroneous—yet few soils are so very deficient in lime as actually to be sterile from the absence of this material. Still, the addition of lime to soils, and even to those which are known to contain already in their composition considerable quantities of it, is found to be so beneficial, in England and in France particularly, that it is very commonly applied to the land for the production of grain crops, &c., and sometimes in as large a quantity as from three hundred to five hundred bushels to the acre, but generally in smaller amount.

Doubtless the lime, when applied in the caustic state, acts to bring to a soluble state some of the nutritious elements which may be locked up in the *insoluble silicates*, and to increase their solubility generally; and enables the soil thus to produce large crops for a few years, making available, during this short time years, perhaps that material which, in the gradual course of the natural disintegration of the harder particles of the soil, might not have been consumed in the smaller harvests for many years, and hence the adage, that "lime enriches

the father and impoverishes the son;" but these analyses have shown, at least in relation to the Kentucky limestones generally, and especially to those easily decomposible limestones of the Lower Silurian formation, that they all contain notable quantities of phosphoric acid, sulphuric acid, potash, soda, magnesia, iron and manganese, &c., and hence, when applied to land, they may not only act beneficially in virtue of the *lime* they contain, but many actually restore to it many of those mineral elements necessary to vegetable growth, which may have been exhausted from the soil by cultivation. The same remarks will apply to the calcareous marls.

The analyses of the Kentucky soils, which have been made, and are published in these volumes, it is hoped may materially aid the enlightened agriculturist, by exhibiting the causes of their fertility, showing the elements which are liable to exhaustion by cultivation, or those which are naturally deficient in soils from various districts, or which may be superabundant; as well as by pointing out, in some cases, the sources whence may be supplied the elements which may be wanting to render soils of certain districts more fertile. Secondarily, it is hoped they may induce the agriculturalist to study more thoroughly the fundamental principles of his noble profession, and thus enable him to attain to the knowledge of the most economical and permanently profitable system of husbandry.

A SUMMARY

OF THE

CHEMICAL ANALYSES

OF

ORES, ROCKS, SOILS, COALS, MINERAL WATERS, &c.,

OF KENTUCKY,

MOSTLY PROCURED BY DAVID DALE OWEN, M. D., PRINCIPAL GEOLOGIST OF KENTUCKY, AND ANALYZED BY ROBERT PETER, M. D., CHEMICAL ASSISTANT TO THE STATE GEOLOGICAL SURVEY.

ARRANGED IN THE ALPHABETICAL ORDER OF THE COUNTIES IN WHICH THEY WERE OBTAINED.

ANDERSON COUNTY.

No. 557—Soil. *Labeled "Virgin soil, from John M. Walker's farm; considered the best adapted to wheat and timothy; will yield twenty bushels to the acre if well attended; white oak-land; near Lawrenceburg, Anderson county, Kentucky. Blue limestone formation."*

The dried soil is of a dark-brownish-grey color; washed carefully with water this soil left 73.65 per cent. of *sand*, of which all but 5.64 per cent. passed through the finest bolting-cloth. This coarser portion was principally composed of small rounded ferruginous concretions, mixed with rounded quartzose particles.

One thousand grains of this soil, dried at the ordinary temperature, digested for a month in a close bottle, in water which had been charged with carbonic acid gas, under a pressure of about two atmospheres, gave up more *than two grains of greyish-brown extract dried at 212°*, which contained the following ingredients, viz:

	Grains.
Organic and volatile matters,	0.430
Alumina, and oxide of iron and phosphates,	.118
Carbonate of lime,	1.178
Magnesia,	.040
Brown oxide of manganese,	.079
Sulphuric acid,	.058
Potash,	.084
Soda,	.034
Silica,	.180
	2.201

Dried at 400° F., this soil lost 4.125 per cent. of *moisture*, and was found to have the following *composition:*

Organic and volatile matters,	5.463
Alumina,	1.615
Oxide of iron,	6.305
Carbonate of lime,	.345
Magnesia,	.335
Brown oxide of manganese,	.315
Phosphoric acid,	.181
Sulphuric acid,	.056
Potash,	.156
Soda,	.023
Sand and insoluble silicates,	84.845
Loss,	.361
	100.000

No. 558—SOIL. *Labeled "Same soil as the last, from John M. Walker's land, near Lawrenceburg, Anderson county, Kentucky; from an old field which has been from twenty to thirty years in cultivation; for four of the latter years in timothy and clover; now in corn; no green crops have ever been turned in. Blue limestone formation."*

Color of the dried soil slightly lighter than that of the preceding soil. The *sand* left by washing this soil in water amounted to 71.1 per cent, of which only 4.91 per cent. was too coarse to pass through the finest-bolting cloth; the coarser particles are principally ferruginous, with a few rounded grains of different colored quartz.

One thousand grains of the air-dried soil, digested in water containing carbonic acid, as before described, gave up about *two grains of*

brownish-grey extract, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.370
Alumina, and oxide of iron and phosphates,	.159
Carbonate of lime,	1.058
Carbonate of magnesia,	.153
Brown oxide of manganese, not determined.	
Sulphuric acid,	.013
Potash,	.119
Soda.	
Silica,	.094
Loss,	.139
	2.105

The air-dried soil lost 3.075 per cent. of *moisture*, when dried at 400° F.

Its *composition*, thus dried, is as follows:

Organic and volatile matters,	4.332
Alumina,	2.165
Oxide of iron,	2.890
Carbonate of lime,	.215
Magnesia,	.465
Brown oxide of manganese,	.220
Phosphoric acid,	.103
Sulphuric acid,	.032
Potash,	.101
Soda,	.047
Sand and insoluble silicates,	89.140
Loss,	.290
	100.000

No. 559—SUB-SOIL. *Labled "From Jno. M. Walker's land, near Lawrenceburg, Anderson county, Kentucky. Blue limestone formation," &c., &c.*

The color of this sub-soil, air-dried, is greyish-buff. Washed with water it left 66.55 per cent. of *sand*, of which all but 4.14 per cent. passed through the finest bolting-cloth; this coarser portion consisted of small rounded ferruginous particles, with a few quartz grains.

One thousand grains, air-dried, gave up to the carbonated water not *quite a grain of grey-brown extract*, dried at 212° F., which had the following *composition:*

Organic and volatile matters,	0.200
Alumina, and oxide of iron and phosphates,	.069
Carbonate of lime,	.318
Magnesia,	.020
Brown oxide of manganese.	
Sulphuric acid,	.026
Potash,	.027
Soda,	.019
Silica,	.110
	0.789 of a gr.

The air-dried sub-soil lost 3.25 per cent. of *moisture*, when dried at 400°, and then had the following *composition*, viz:

Organic and volatile matters,	3.213
Alumina,	2.465
Oxide of iron,	3.555
Carbonate of lime,	.070
Magnesia,	.601
Brown oxide of manganese,	.220
Phosphoric acid,	.142
Sulphuric acid,	.056
Potash,	.130
Soda,	.026
Sand and insoluble silicates,	88.970
Loss,	.552
	100.000

This sub-soil does not appear to be richer than the surface soil, in the *mineral* food of plants, while it contains less *organic matters;* the turning of it up with the sub-soil plough, therefore, promises only to improve the soil *mechanically*.

It will be seen, by comparing the analyses of the soil of the old field, which has been twenty to thirty years in cultivation, with that of the virgin soil, that the former has lost a portion of all those ingredients which enter into the composition of vegetables, with the exception of soda, magnesia, and oxide of manganese, and that, particularly, the lime, and potash, the phosphoric and sulphuric acids, have been sensibly diminished, by the course of cropping, whilst the relative proportion of the silica and insoluble silicates, alumina and oxide of iron, have been increased, and the amount of organic matters reduced. The soil of the old field also gave up less of soluble matter, when digested

in water containing carbonic acid, and is slighly lighter in color than that.

When the two preceding soils, Nos. 557 and 558, were submitted to analyses, the labels had been accidentally interchanged, without the knowledge of the writer, whilst taking out specimens of each for the state cabinet; the former, therefore, was labeled "soil from an old field," and the latter "virgin soil;" the analyses of the two, however, showed the differences of composition just pointed out, and led the author to suspect that some mistake had been made in the labels. On writing to Mr. Walker to send additional specimens, or to compare the two soils, side by side, and send word which had the darker color, it was found, on his response, that the suspicion in regard to the change of labels was correct, and thus was established, in these soils, as with most of the specimens of soils which have been submitted to examination at this laboratory, the accuracy of the indications of their comparative chemical analysis, in relation to their gradual exhaustion by the process of cropping: the same thing occurred with the set of soils from G. Threlkeld's farm, Owen county.

The calculation of the amount of nutricious materials which have been withdrawn from the soil No. 558, by the course of twenty to thirty years cropping, as compared with the virgin soil No. 557, can be easily made. Supposing the soil to weigh about 71½ pounds to the cubic foot, as was found, by experiment, to be the fact with the Fayette county soil, (see former report, Fayette county,) the 43,560 cubic feet of earth on the acre of ground, taken to the depth of one foot, would weigh a little more than three millions of pounds. Let us, for example, carry out the figures in regard to the *potash* and *phosphoric acid* alone, in these two soils:

In soil No. 557 the phosphoric acid amounts to	0.156 per cent.
In soil No. 558 the phosphoric acid amounts to	.111 per cent.
Difference, - - - -	0.045 per cent.

Now 0.156, the quantity in 100 pounds of the soil, multiplied by 3,000,000, and divided by 100, gives 4,680, the number of pounds of potash in an acre of the virgin soil; and 0.111, multiplied by the same number, &c., gives only 3,330, the number of pounds contained in the soil of the old field; the difference, 1,350 pounds, shows the amount of this substance which the old soil has lost in the course of

twenty to thirty years cultivation. So in regard to the *phosphoric acid*, equal to 0.181 per cent. in the virgin soil, or six thousand four hundred and thirty pounds (6,430 pounds) to the acre, and 0.103 per cent. or three thousand and ninety pounds (3,090 pounds) to the acre; the diminution produced by the cropping amounts to three thousand three hundred and forty pounds (3,340 pounds,) to the acre.

BATH COUNTY.

The waters from five different sources, at the Olympian Springs, in this county, were *qualitatively* tested by the writer some eight years ago, and as he has not yet had the opportunity of fully analyzing these valuable waters, he thinks it proper to append to this report the account of the testing made at that time.

No. 560—Mineral Water. *Labeled "Sweet Spring, near Pound Lick," Olympian Springs, Bath county, Kentucky.*

One thousand grains of the water left 1.5 grains of dry saline matter, on evaporation.

This water was found to contain,

Carbonic acid gas;

Bi-carbonate of lime;

Bi-carbonate of magnesia;

Bi-carbonate of iron;

Chloride of sodium, (common salt;)

And sulphate of soda.

This is a weak *saline chalybeate* water. All the iron separates from it on standing or boiling. Boiling also causes the deposition of most of the carbonates of lime and magnesia.

No. 561—Mineral Water. *Labeled "Chalybeate Spring," Olympian Springs, Bath county, Kentucky.*

One thousand grains of this water left only 0.75 of a grain of dry saline matter on evaporation.

It was found to contain—

Carbonic acid;

Bi-carbonate of lime, magnesia and iron;

Sulphates of magnesia and lime, in small quantities;

And traces of carbonate of soda and chloride of sodium.

This water resembles the preceding in its composition, containing a larger proportion of iron than that. All these chalybeate waters must be used *fresh from the spring*, when the full action of the dissolved carbonate of the protoxide of iron is desired, as it is very speedily precipitated when the water is allowed to stand exposed to the air, or when it is boiled. Even the small quantity of air which is usually left in the neck of a bottle, when it is corked, is sufficient to displace all the carbonic acid from the dissolved carbonate, and cause the whole of the iron to fall down as insoluble peroxide. After the iron is precipitated from this water very little saline matter remains dissolved in it.

No. 562—MINERAL WATER. *Labeled "Tea Spring or White Sulphur, Olympian Springs," Bath county, Kentucky.*

One thousand grains of this water, on evaporation to dryness, left 0.5 of a grain of saline matter.

It contains—

Sulphuretted hydrogen gas, in small quantity;

Carbonic acid gas;

Bi-carbonates of lime and magnesia, in small proportions;

Bi-carbonates of iron and soda, in considerable proportions;

Sulphate of soda, in small proportions;

Chloride of sodium, in small proportions.

This is a *good saline alkaline chalybeate.* It is a remarkably soft water after boiling has thrown down the oxide of iron and the earthy carbonates.

No. 563—MINERAL WATER. *Labeled "Salt Sulphur, from the Saloon," Olympian Springs, Bath county, Kentucky.*

One thousand grains of this water, evaporated to dryness, left 5.8 grains of *saline matters.*

It was found to contain—

Sulphuretted hydrogen gas;

Carbonic acid gas;

Bi-carbonates of lime and magnesia, in small proportions;

Chloride of sodium, in large proportion;

Chloride of calcium, in small proportion;

Carbonate of iron, a trace;

Carbonate of soda, a trace;

Iodide of sodium, a small proportion.

This is evidently a very valuable medicinal mineral water, more particularly from the fact that it contains *iodine*, the value of which, in many chronic diseases, is well known to physicians. This water should be thoroughly analyzed, and the relative proportions of its several ingredients, as they exist in the water fresh from the well, should be accurately ascertained. This would require, however, a visit to the spring, and the evaporation of several gallons of the water, for which there has been no time up to the preparation of this report.

No. 564—MINERAL WATER. *Labled "Black Sulphur," Olympian Springs, Bath County, Kentucky.*

One thousand grains of this water were found to contain about one grain of dry saline matter.

The dissolved ingredients of this water, are

Sulphuretted hydrogen gas;

Carbonic acid gas;

Chloride of sodium,
Carbonate of soda, } in considerable proportions;

Bi-carbonate of lime,
Sulphate of soda,
Bi-carbonate of iron, } in small proportions;

Other ingredients could doubtless be found, by operating on larger quantities of the water. This a good *alkaline sulphur water.*

BOONE COUNTY.

No. 565.—SOIL. *Labeled "Soil from a beech-wood pasture, which has never been in cultivation, Sandford farm, near Union, Boone county, Kentucky. Blue limestone, of the Lower Silurian formation."*

The air-dried soil is of a light mouse-color.

One thousand grains, washed with water, left 855. grains of fine *sand*, of which all but 40.3 grains passed through the finest bolting-cloth. This coarser portion of the sand is composed of small rounded particles of clear and yellow quartz, and of a ferruginous mineral. One thousand grains, air-dried, digested for a month in water containing carbonic acid, gave up more than four and a half grains of buff-grey *extract*, dried at 212° F. The *composition* of which was found to be as follows:

	Grains.
Organic and volatile matters,	0.930
Alumina, oxides of iron and manganese, and phosphates,	.563
Carbonate of lime,	2.330
Magnesia,	.190
Sulphuric acid,	.074
Potash,	.223
Soda,	.026
Silica,	.187
Loss,	.077
	4.600

The air-dried soil lost 4.635 per cent. of *moisture* when dried at 400° F.; and its composition, thus dried, is as follows:

Organic and volatile matters,	7.827
Alumina,	2.495
Oxide of iron,	2.790
Carbonate of lime,	.395
Magnesia,	.495
Brown oxide of manganese,	.195
Phosphoric acid,	.318
Sulphuric acid,	.084
Potash,	.173
Soda,	.040
Sand and insoluble silicates,	84.620
Loss,	.568
	100.000

No. 566—SOIL. *Labeled "Same soil (as preceding,) from an old field twenty to thirty years in cultivation, Sandford farm, near Union, Boone county, Kentucky. Blue limestone of the Lower Silurian formation."*

Color of the dried soil brownish-grey. The *sand* washed out from a thousand grains of this soil weighed 787.7 grains, and except 30.7 grains, was fine enough to pass through the bolting cloth. The coarser particles are principally rounded ferruginous grains, with some of clear and colored quartz. One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than three grains of *light brown extract*, which had the following *composition*, dried at 212° F.:

Organic and volatile matters,	0.380
Alumina, oxides of iron and manganese, and phosphates,	.240
Carbonate of lime,	1,947
Magnesia,	.136
Sulphuric acid,	.045
Potash,	.082
Soda,	.005
Silica,	.110
Loss,	.155
	3.100

The air-dried soil lost 3.75 per cent. of moisture, at 400° F.; dried at which temperature it has the following *composition*, viz:

Organic and volatile matters,	5.506
Alumina,	3.520
Oxide of iron,	3.124
Carbonate of lime,	.495
Magnesia,	.469
Brown oxide of manganese,	.245
Phosphoric acid,	.126
Sulphuric acid,	.187
Potash,	.152
Soda,	.032
Sand and insoluble silicates,	85.595
Loss,	.549
	100.000

No. 567—SUB-SOIL. *Labeled "Sub-soil from the old field, twenty to thirty years in cultivation, Sandford farm, near Union, Boone county, Kentucky. Blue limestone of Lower Silurian formation."*

Dried sub-soil of a brownish-buff color, having a slightly more reddish tint than the preceding; in cloddy lumps. Washed with water, it gave 76.83 per cent. of *sand*, &c., of which all but 1.08 per cent. passed through the finest bolting-cloth. This coarser portion was principally composed of small rounded particles of ferruginous matter, with some grains of clear and yellowish quartz. One thousand grains, air-dried, gave to the carbonated water nearly two grains of *light grey extract*, dried at 212° F., which contained the following ingredients, viz:

Organic and volatile matters,	0.277
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	1.120
Magnesia,	.139
Sulphuric acid,	.022
Potash,	.066
Soda,	.008
Silica,	.241
	1.936

The air-dried sub-soil lost 3.19 per cent. of *moisture* at 400° F., and has the following *composition*, viz :

Organic and volatile matters,	3.455
Alumina,	3.945
Oxide of iron,	3.420
Carbonate of lime,	.265
Magnesia,	.536
Brown oxide of manganese,	.295
Phosphoric acid,	.476
Sulphuric acid,	.067
Potash,	.213
Soda,	.050
Sand and insoluble silicates,	87.645
	100.367

By comparing the several analyses of these soils, it will be seen that the soil from the old field has lost a notable quantity of its organic and volatile matters, its phosphoric acid and alkalies, while it exhibits a larger proportion of alumina and oxide of iron, and of sand and insoluble silicates, than the virgin soil; doubtless owing, in part, to some admixture with it of the sub-soil. The sub-soil is seen to be somewhat richer in phosphoric acid and potash, than even the virgin soil, and hence benefit may result from the use of the sub-soil plough in cultivation.

BOURBON COUNTY.

No. 568—SOIL. *Labeled "Virgin soil, from Wm. P. Humes' farm, between the waters of Houston creek and Cooper's run; primitive forest growth, blue and black ash, honey locust, walnut, sugar tree, wild cherry, &c. Blue limestone of Lower Silurian formation. Bourbon county, Kentucky."*

The dried soil is of a yellowish-umber color.

Washed with water this soil left 88.13 per cent. of sand, &c., of which all but 18.06 per cent. passed through the finest bolting-cloth. This coarser portion is composed of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up *more than six grains of* light brown extract, dried at 212°, of the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.133
Alumina, oxides of iron and manganese, and phosphates,	.672
Carbonate of lime,	3.630
Magnesia,	.194
Sulphuric acid,	.039
Potash,*	.164
Soda,	.065
Silica,	.181
	6.078

The air-dried soil lost 5.10 per cent. of moisture at 400° F., and has the following *composition*, viz:

Organic and volatile matters,	8.406
Alumina,	5.745
Oxide of iron,	5.185
Carbonate of lime,	.945
Magnesia,	.170
Brown oxide of manganese,	.370
Phosphoric acid,	.335
Sulphuric acid,	.119
Potash,	.227
Soda,	.133
Sand and insoluble silicates,	79.045
	100.680

No. 569—SOIL. *Labeled "Soil from an old field, sixty years in cultivation; for some forty years in grass; same growth, &c., &c., as the preceding virgin soil; from Wm. P. Hume's farm, Bourbon county, Kentucky."*

From both of these soils the coarse seive removed irregular fragments of decomposed chert, of limestone, and soft rounded ferrugi-

nous particles. The color of the dried soil is somewhat lighter and browner than that of the preceding.

Washed with water it left 78.56 per cent. of sand, &c., of which all but 6.83 per cent. passed through fine bolting-cloth; this coarser portion consists of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up 3.149 grains of brownish *extract*, dried at 212°, which consisted of,

Organic and volatile matters,	0.517
Alumina, oxides of iron and manganese, and phosphates,	.422
Carbonate of lime,	1.830
Magnesia,	.105
Sulphuric acid,	.025
Potash,	.078
Soda,	.075
Silica,	.097
	3.149

The air-dried soil lost 3.84 per cent. of *moisture*, at 400° F., and has the following *composition*, viz:

Organic and volatile matters,	5.574
Alumina,	4.925
Oxide of iron,	4.185
Carbonate of lime,	.485
Magnesia,	.110
Brown oxide of manganese,	.395
Phosphoric acid,	.330
Sulphuric acid,	.085
Potash,	.209
Soda,	.114
Sand and insoluble silicates,	83.310
Loss,	.278
	100.000

No. 570—SUB-SOIL. *Labeled "Sub-soil from the same old field, Wm. P. Hume's farm, Bourbon county, Kentucky."*

The coarse seive removed from this sub-soil fragments of chert and ferruginous particles. The color of the air-dried sub-soil is somewhat lighter than that of the preceding. Washed with water this sub-soil left 79.17 per cent. of sand, &c., of which all but 6.80 per cent. pass-

ed through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for twenty days in water containing carbonic acid, gave up 2.263 grains of yellowish-grey *extract*, dried at 212° F., which was composed of

	Grains.
Organic and volatile matters,	0.308
Alumina, oxides of iron and manganese, and phosphates,	.205
Carbonate of lime,	1.413
Magnesia,	.075
Sulphuric acid,	.022
Potash,	.062
Soda,	.062
Silica,	.114
	2.263

The air-dried sub-soil lost 3.84 per cent. of moisture at 400° F.; dried at which temperature its *composition* is as follows:

Organic and volatile matters,	4.196
Alumina,	5.360
Oxide of iron,	4.313
Carbonate of lime,	.355
Magnesia,	.521
Brown oxide of manganese,	.420
Phosphoric acid,	.440
Sulphuric acid,	.085
Potash,	.195
Soda,	.100
Sand and insoluble silicates,	84.070
	100.055

It is interesting to observe, that although the soil of the *old field*, in the preceding soils, has been sixty years under cultivation, it has lost much less of its phosphoric acid, sulphuric acid, and potash than might be expected from the lapse of time. This, doubtless, may be attributed to the fact that for most of this period—about forty years—the land has been in grass.

The immediate sub-soil of the old field does not show a much larger proportion of phosphoric acid than the virgin soil, while it contains less potash; but the red under-clay, next to be described, like most of the red under-clays on the blue limestone formation, exhibits a remarkable richness in this alkali.

No. 571—"RED UNDER-CLAY, *with fragments of cherty rock and fossil shells,* (*Terebratula capax and Orthis testudinaria,*) *Capt. Wm. Hume's farm, Bourbon county, Kentucky.*"

Color, slightly lighter than that of the preceding, and of a purer brownish buff. Washed with water this under-clay left 69.67 per cent. of sand, &c., of which all but 11.93 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consists of small rounded ferruginous particles.

One thousand grains of the air-dried clay, digested for twenty days in water containing carbonic acid, gave up 1.834 grains of light-grey *extract*, dried at 212°, which had the following *composition*, viz:

Organic and volatile matters, - - - - - - - -	0.266
Alumina, oxides of iron and manganese, and phosphates, - -	.063
Carbonate of lime, - - - - - - - - - -	1.155
Magnesia, - - - - - - - - - - - -	.067
Sulphuric acid, - - - - - - - - - - -	.016
Potash, - - - - - - - - - - - -	.046
Soda, - - - - - - - - - - - -	.040
Silica, - - - - - - - - - - - -	.181
	1.834

The air-dried clay lost 6.45 per cent. of moisture at 400° F., and has the following *composition*, viz:

Organic and volatile matters, - - - - - - - -	4.783
Alumina, - - - - - - - - - - - -	12.785
Oxide of iron, - - - - - - - - - - -	9.420
Carbonate of lime, - - - - - - - - - -	6.235
Magnesia, - - - - - - - - - - -	1.946
Brown oxide of manganese, - - - - - - - -	.495
Phosphoric acid, - - - - - - - - - -	.425
Sulphuric acid, - - - - - - - - - - -	.050
Potash, - - - - - - - - - - - -	.840
Soda, - - - - - - - - - - - -	.116
Sand and insoluble silicates, - - - - - - - -	63.770
	100.865

Gradually mixed with the exhausted upper soil, by trenching or deep sub-soil plowing, this under-clay would improve it by furnishing a new supply of potash, phosphoric acid, and lime.

No. 572—LIMESTONE. *Labeled "Atrypa capax limestone, under the soil of Capt. Wm. P. Hume's land, Bourbon county, Kentucky." Lower Silurian.*

A crystalline, coarse-granular, light-grey, limestone, containing many shells and corals; very much eroded and cellular on the exterior, where it is of a brown color.

Composition, dried at 212° F.—

Carbonate of lime,	81.340	= 45.645 of *Lime*.
Carbonate of magnesia,	.979	
Alumina, and oxides of iron and manganese,	.640	
Phosphoric acid,	.221	
Sulphuric acid,	.324	
Potash,	.104	
Soda,	.177	
Sand and insoluble silicates.	16.646	
	100.431	

No. 573—LIMESTONE. *Labeled "Shell limestone, near the surface, Capt. Wm. P. Hume's farm, Bourbon county, Kentucky. Lower Silurian formation."*

A grey limestone, full of fossil shells, chætetes, &c., and sparkling with crystalline grains of calcareous spar; weathered surface nearly even, brownish.

Composition, dried at 212° F.—

Carbonate of lime,	94.680	= 53.13 of *Lime*.
Carbonate of magnesia,	.980	
Alumina, and oxides of iron and manganese,	1.120	
Phosphoric acid,	.196	
Sulphuric acid,	.592	
Potash,	.166	
Soda,	.233	
Insoluble silicates,	1.086	
Loss,	.947	
	100.000	

Limestones, so rich in phosphoric acid, sulphuric acid, and the alkalies, and at the same time so easily decomposed under the atmospheric influences, always exert a marked enriching effect on the soil which rests upon them.

No. 574—SOIL. *Labeled "Virgin soil, woods pasture, Wm. Buckner's farm, Cane ridge land; primitive forest growth, large buckeye, oak, honey-locust, sugar-tree, &c. Lower Silurian formation. Bourbon county, Kentucky."*

The dried soil is of a greyish-brown color Washed with water this soil left 83.83 per cent. of sand, &c., of which all passed through the finest bolting-cloth except about 5.34 per cent., which was composed of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up *more than six and a half grains of brown extract*, dried at 212° F., which was found to have the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.975
Alumina, oxides of iron and manganese, and phosphates,	1.588
Carbonate of lime,	2.763
Magnesia,	.058
Sulphuric acid,	.065
Potash,	.154
Soda,	.068
Silica,	.089
	6.760

The air-dried soil lost 5.865 per cent. of moisture at 400° F. Thus dried its *composition* is as follows, viz:

Organic and volatile matters,	7.702
Alumina,	4.620
Oxide of iron,	6.685
Carbonate of lime,	.622
Magnesia,	.508
Brown oxide of manganese,	.720
Phosphoric acid,	.321
Sulphuric acid,	.145
Potash,	.224
Soda,	.077
Sand and insoluble silicates,	78.680
	100.204

No. 575—SOIL. *Labeled "Soil from an old corn-field, forty to fifty years in cultivation, (same locality and primitive forest growth as the*

preceding, Wm. Buckner's farm, &c., &c.) Bourbon county, Kentucky."

The dried soil is slightly lighter colored, and more yellowish than the preceding.

Washed with water it left 71.28 per cent. of sand, &c., of which all but 7.46 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, *gave up nearly three grains of light-brownish-grey extract*, dried at 212°, which was found to have the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.583
Alumina, oxides of iron and manganese, and phosphates,	.496
Carbonate of lime,	1.305
Magnesia,	.088
Sulphuric acid,	.045
Potash,	.102
Soda,	.076
Silica,	.139
	2.834

The air-dried soil lost 4.5 per cent. of moisture, at 400° F., and, thus dried, has the following *composition*, viz:

Organic and volatile matters,	5.837
Alumina,	5.195
Oxide of iron,	5.910
Carbonate of lime,	.446
Magnesia,	.416
Brown oxide of manganese,	.593
Phosphoric acid,	.282
Sulphuric acid,	.101
Potash,	.248
Soda,	.103
Sand and insoluble silicates,	81.080
	100.211

No. 576—SUB-SOIL. *Labeled "Sub-soil from the same old field, at Wm. Buckner's farm, Cane ridge, Bourbon county, Kentucky.*"

Cloddy; color lighter and more yellowish than that of the two preceding.

Washed with water this sub-soil left 71.90 per cent. of sand, &c., of which all but 6.97 per cent. passed through the finest bolting-cloth. This coarser portion consists of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for twenty days in the water, containing carbonic acid, *gave up* 2.671 *grains of yellowish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.442
Alumina, and oxides of iron and manganese, and phosphates,	.222
Carbonate of lime.	1.530
Magnesia,	.136
Sulphuric acid,	.045
Potash,	.064
Soda,	.060
Silica,	.172
	2.671

The air-dried sub-soil lost 4.60 per cent. of moisture at 400° F.; thus dried it has the following *composition*, viz:

Organic and volatile matters,	4.785
Alumina,	5.295
Oxide of iron,	5.660
Carbonate of lime,	.421
Magnesia,	.517
Brown oxide of manganese,	.345
Phosphoric acid,	.243
Sulphuric acid,	.110
Potash,	.217
Soda,	.130
Sand and insoluble silicates,	82.230
Loss,	.047
	100.000

No. 577.—UNDER-CLAY. *Labeled "Under-clay, with bog iron ore, from Wm. Buckner's land, Cane ridge, Bourbon county, Kentucky."*

Color of the dried clay greyish-buff. Washed with water it left 71.36 per cent. of sand, &c., of which all but 16.96 per cent. passed through the fine bolting cloth; this coarser part was composed of small rounded ferruginous particles.

One thousand grains of the air-dried under-clay, digested for twenty days in water containing carbonic acid, gave up *less than two grains*

of yellowish grey extract, dried at 212° F., which was found to consist of

	Grains.
Organic and volatile matters,	0.525
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	.913
Magnesia,	.125
Sulphuric acid,	.022
Potash,	.020
Soda,	.075
Silica,	.106
	1.849

The air-dried under-clay lost 7.085 per cent. of *moisture*, at 400° F., dried at which temperature its *composition* was found to be as follows, viz:

Organic and volatile matters,	4.875
Alumina,	8.720
Oxide of iron,	10.015
Carbonate of lime,	.446
Magnesia,	.753
Brown oxide of manganese,	.470
Phosphoric acid,	.221
Sulphuric acid,	.093
Potash,	.347
Soda,	.159
Sand and insoluble silicates,	74.145
	100.000

On comparing the analyses of this series of soils from Bourbon county, the usual fact will be observed of the diminution, in the old soil, of the materials necessary for the nourishment of vegetables, as compared with the original virgin soil. It will be seen that in the soil of the old corn-field, which has been from forty to fifty years in cultivation, there is less organic matter, less carbonate of lime, magnesia, oxide of manganese, phosphoric and sulphuric acids, than in the original soil, and that the former soil, lighter colored because it contains less organic matter, for the same reason, perhaps, is capable of holding a smaller proportion of hygrometric moisture than the latter. But the anomaly appears, which was seldom seen in the course of the examination of the soils of Kentucky, of a slightly larger amount of potash

in the soil of the old field than in the virgin soil. There is a possibility, however, that some undiscovered error may have occurred in the analysis, which, as this series of soils was submitted to examination just before this report was required to be made, could not be rectified by a repetition of the processes; but, on the other hand, there may have been a natural difference of composition in relation to their proportions of potash in the soils of these two neighboring fields. Moreover, the ordinary mode, in Bourbon and the neighboring counties, of feeding down on the same field, with hogs and cattle, the corn which has been raised on it, does not by any means exhaust the soil of the potash, like the removal of the crop from the ground, without the return to it of manure.

It will be seen that the under-clay, containing much more oxide of iron and less alumina than that under Capt. Wm. R. Hume's land, on the waters of Huston creek, contains also less potash, lime, and phosphoric acid. It yet contains enough of these to prove a valuable resource to renew the exhausted upper soil.

No. 578—LIMESTONE. *Labeled "Crystalline lime-rock, quarry below the woods pasture, on Wm. Buckner's land, Cane ridge, Bourbon county, Kentucky. Lower Silurian formation."*

A limestone which is principally made up of large, pure, crystalline grains, with some little ochreous oxide of iron in spots throughout it; no fossils apparent in the specimen examined; weathered surface brownish.

Composition, dried at 212° F.—

Carbonate of lime,	97.540	= 53.735 per cent. of *Lime*.
Carbonate of magnesia,	.699	
Alumina, and oxides of iron and manganese,	.287	
Phosphoric acid,	.093	
Sulphuric acid,	.180	
Potash,	.065	
Soda,	.206	
Insoluble silicates,	1.446	
	100,516	

No. 579—LIMESTONE. *Labeled "Chaetetes limestone, below the woods pasture at Wm. Buckner's, Cane ridge, Bourbon county, Kentucky. Lower Silurian formation."*

A grey limestone, full of fossil shells and coral, and sparkling with crystalline grains of calcareous spar. Weathered surface irregular, and of a brownish color.

Composition, dried at 212° F.—

Carbonate of lime,	95.480	= 53.58 per cent. of *Lime*.
Carbonate of magnesia,	1.398	
Alumina, and oxides of iron and manganese,	.797	
Phosphoric acid,	.183	
Sulphuric acid,	.180	
Potash,	.085	
Soda,	.138	
Insoluble silicates,	2.326	
	100.587	

Purer limestones than those under Mr. Hume's land, but not quite so rich as those in the elements of vegetable nourishment.

BOYLE COUNTY.

No. 580—SOIL. *Labeled "Virgin soil from Thomas Read's woods pasture, one mile from Danville; primitive forest growth principally sugar-tree, hickory, ash, and walnut. Lower Silurian formation. Boyle county, Kentucky."*

The color of the dried soil is yellowish-brown; some ferruginous and cherty gravel was sifted out of it with the coarse seive. Washed with water it left 89.7 per cent. of sand, &c., of which all but 2.78 per cent. was fine enough to pass through the finest bolting-cloth. This coarser part consists of rounded ferruginous and cherty particles.

One thousand grains of the air-dried soil, digested for one month in water charged with carbonic acid, gave up to it more than five and a half grains of *chestnut-brown extract*, dried at 212°, which contained the following ingredients, viz:

	Grains.
Organic and volatile matters,	2.030
Alumina, oxides of iron and manganese, and phosphates,	.873
Carbonate of lime,	1.907
Magnesia,	.084
Sulphuric acid,	.090
Potash,	.579
Soda,	.087
Silica,	.033
	5.683

The air-dried soil lost 3.50 per cent. of moisture at 400° F.; dried at which temperature its *composition* is as follows, viz:

Organic and volatile matters,	5.958
Alumina,	3.515
Oxide of iron,	3.835
Carbonate of lime,	.247
Magnesia,	.571
Brown oxide of manganese,	.320
Phosphoric acid,	.486
Sulphuric acid,	.119
Potash,	.183
Soda,	.071
Sand and insoluble silicates,	83.770
Loss,	.925
	100.000

Rich *blue-grass* soil, containing, particularly, a large proportion of phosphoric acid, but not quite as much potash as most of the best soils on the blue limestone formation.

BRECKINRIDGE COUNTY.

No. 581—SOIL. *Labeled "Virgin soil, from the level table-land near Hardinsburg, from over the sandstone superimposed on the Archimedes limestone, which is some forty or fifty feet below; primitive forest growth black oak, hickory, dogwood, sassafras, and some wild cherry. This soil represents a considerable tract about this place, and between it and the Ohio river. Breckinridge county, Kentucky."*

The dried soil is of a dirty grey-cinnamon color; a small quantity of ferruginous and quartzose gravel was sifted out of it with the coarse seive. Washed with water this soil left 82.7 per cent. of sand, &c., of which all but 1.39 per cent. was fine enough to go through the bolting cloth. This coarser portion consisted principally of rounded particles of a soft ferruginous mineral, with very few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up to it nearly two grains of *brownish ex:ract*, dried at 212° F, which was found to consist of,

	Grains.
Organic and volatile matters,	0.630
Alumina, oxides of iron and manganese, and phosphates,	.196
Carbonate of lime,	.170
Magnesia,	.170

Sulphuric acid,	.070
Potash,	.210
Soda,	.050
Silica,	.280
Loss,	.051
	1.827

The air-dried soil lost 2.625 per cent. of *moisture* at 400° F.; and, when thus dried, was found to have the following *composition*, viz:

Organic and volatile matters,	3.532
Alumina,	2.080
Oxide of iron,	2.215
Carbonate of lime,	.022
Magnesia,	.323
Brown oxide of manganese,	.220
Phosphoric acid,	.108
Sulphuric acid,	.059
Potash,	.194
Soda,	.017
Sand and insoluble silicates,	91.145
Loss,	.085
	100.000

This soil exhibits a very large proportion of sand and insoluble silicates, and a remarkable deficiency of lime. The application to it of marl containing a considerable quantity of lime would be found to be beneficial. If the marl is rich also in phosphoric acid or phosphates it would be still better, as the proportion of that acid contained in the soil is less than usual.

No. 582—Soil. *Labeled "Shallow soil, overlying the buff and white Archimedes and Productus beds of the sub-carboniferous limestone of Breckinridge county, Kentucky; taken three and a half miles west of Hardinsburg. This soil supports a small growth of oak and hickory."*

The dried soil is of a light mouse color; the coarse seive removed from it some fragments of ferruginous sandstone. Washed with water it left 84.33 per cent. of sand, &c., of which all but 2.17 per cent. was fine enough to pass through bolting-cloth.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up nearly two grains of *dark-brown extract*, dried at 212° F. This has the following *composition:*

	Grains.
Organic and volatile matters,	0.850
Alumina, oxides of iron and manganese, and phosphates,	.313
Carbonate of lime,	.047
Magnesia,	.078
Sulphuric acid,	.042
Potash,	.119
Soda,	.039
Silica,	.133
Loss,	.279
	1.900

The air-dried soil lost 2.60 per cent. of *moisture* at 400° F. Its *composition*, thus dried, is as follows, viz:

Organic and volatile matters,	5.030
Alumina,	1.640
Oxide of iron,	1.490
Carbonate of lime,	.147
Magnesia,	.285
Brown oxide of manganese,	.095
Phosphoric acid,	.139
Sulphuric acid,	.042
Potash,	.198
Soda,	.020
Sand and insoluble silicates,	90.420
Loss,	.494
	100.000

This differs but little, in general composition, from the preceding; it contains, however, rather more carbonate of lime and organic matters; apart from these the proportion of sand and insoluble silicates is fully as large as in that soil, there being a little less of alumina and oxide of iron. The addition of aluminous marl which is rich in lime, phosphates, and potash, would also greatly improve this soil.

BULLITT COUNTY.

No. 583—SOIL. *Labeled "Soil from the flats near Shepherdsville, derived chiefly, from the Black Devonian shale, at the base of the knobs, and the overlying ash-colored shales, which are most probably the lowest sub-carboniferous; considered almost unfit for cultivation, except for grass; too wet and unproductive, and but little cultivated; primitive growth oak, beech, black hickory, &c. Bullitt county, Kentucky."*

The dried soil is of an ash-grey color, and is quite cloddy, so that it was with difficulty passed through the seive. Washed with water it left 54.9 per cent. of sand, &c., of which all but 10.5 per cent. was fine enough to go through the finest bolting cloth. This coarser part consisted of rounded ferruginous and quartzose particles.

One thousand grains, digested for a month in water containing carbonic acid, gave up about two grains of grey-brown extract, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.630
Alumina, oxides of iron and manganese, and phosphates,	.598
Carbonate of lime,	.223
Magnesia,	.050
Sulphuric acid,	.226
Potash,	.065
Soda,	.030
Silica,	.200
	2.022

The air-dried soil lost 4.68 per cent of *moisture* at 380° F.; dried at which temperature it has the following *composition*, viz:

Organic and volatile matters,	5 665
Alumina,	2.476
Oxide of iron,	4.790
Carbonate of lime,	.196
Magnesia,	.526
Brown oxide of manganese,	.176
Phosphoric acid,	.253
Sulphuric acid,	.054
Potash,	.258
Soda,	.058
Sand and insoluble silicates,	85.056
Loss,	.492
	100.000

Thorough drainage would make this very good soil.

No. 584—SOIL. *Labeled "Virgin soil over the magnesian limestone of the Upper Silurian system, Mr. Hall's farm, near Mt. Washington, Bullitt county, Kentucky. Primitive forest growth black, red, and white oak, hickory, dogwood, and some sugar-tree."*

The dried soil is of a greyish-brown color. Some fragments of ferruginous sandstone were sifted out with the coarse seive. Washed with water this soil left 70.47 per cent. of sand, &c., of which only 1.7 per cent. was too coarse to pass through the finest bolting cloth; this consisted principally of soft rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up less than one and a half grains of *brownish extract*, dried at 212° F.; this had the following composition, viz:

	Grains.
Organic and volatile matters, - - - - - - - - -	0.230
Alumina, oxides of iron and manganese, and phosphates, - -	.080
Carbonate of lime, - - - - - - - - - -	.590
Magnesia, - - - - - - - - - - - -	.060
Sulphuric acid, - - - - - - - - - - -	.070
Potash, - - - - - - - - - - - -	.130
Soda, - - - - - - - - - - - -	.080
Silica, - - - - - - - - - - - -	.200
	1.390

The air-dried soil lost 2.92 per cent. of *moisture* at 400°; dried at which temperature its composition was found to be as follows:

Organic and volatile matters, - - - - - - - -	3.120
Alumina, - - - - - - - - - - - - -	2.390
Oxide of iron, - - - - - - - - - - -	2.740
Carbonate of lime, - - - - - - - - - -	.182
Magnesia, - - - - - - - - - - - - -	.348
Brown oxide of manganese, - - - - - - - - -	.165
Phosphoric acid, - - - - - - - - - - -	.097
Sulphuric acid, - - - - - - - - - - -	.067
Potash, - - - - - - - - - - - - -	.145
Soda, - - - - - - - - - - - - - -	.037
Sand and insoluble silicates, - - - - - - - -	90.555
Loss, - - - - - - - - - - - - - -	.154
	100.000

No. 585—Soil. *Labeled "Same soil, which has been from fifty to sixty years in cultivation, from Mr. Hall's farm, near Mt. Washington, Bullitt county, Kentucky. This no longer produces clover."*

The dried soil is of a grey-buff color; lighter than that of the preceding soil. Washed with water this soil left 78.2 per cent. of sand,

&c., of which all but 2.87 per cent. passed through the finest bolting-cloth; this portion consisted principally of rounded ferruginous particles, with some quartzose grains.

One thousand grains of the air-dried soil, digested in water containing carbonic acid, for a month, gave up less than a grain of *dark brown extract*, dried at 212°, the composition of which was as follows, viz:

Organic and volatile matters,	0.317
Alumina, oxides of iron and manganese, and phosphates,	.070
Carbonate of lime,	.097
Magnesia,	.050
Sulphuric acid,	.084
Potash,	.089
Soda,	.013
Silica,	.114
	0.834 of a gr.

The air-dried soil lost 2.725 per cent. of *moisture* at 400°, dried at which temperature it has the following *composition*, viz:

Organic and volatile matters,	3.696
Alumina,	1.890
Oxide of iron,	2.215
Carbonate of lime,	.072
Magnesia,	.320
Brown oxide of manganese,	.145
Phosphoric acid,	.070
Sulphuric acid,	.055
Potash,	.104
Soda,	.058
Sand and insoluble silicates,	91.695
	100.320

The inability of this soil to produce clover is explained by its very small proportion of lime, and rather small amount of sulphuric and phosphoric acids. The addition of Plaster of Paris, or some of the calcareous marls, would probably restore to it the capability of suporting a clover crop. Sub-soil plowing may have some good effect upon it. The proportion of sand and silicates, however, is quite large, and that of the alkalies also quite moderate. The exhaustive influence, on this soil, of the fifty or sixty years cultivation, is well exhibited in the foregoing analyses.

No. 586—SUB-SOIL. *Labled "Sub-soil from the same old field, fifty to sixty years in cultivation, Hall's farm, near Mount Washington, Bullitt county, Kentucky."*

Color of the dried soil darker and more reddish than that of the preceding. Washed with water it left 34.3 per cent. of sand, &c., of which all but 1.43 per cent. passed through the bolting cloth; this portion consisted of round particles of ferruginous mineral, with a few quartzose.

One thousand grains of the air-dried soil, digested for a month in water which was charged with carbonic acid, gave up about a grain and a third of *brownish-grey extract*, dried at 212°; which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.270
Alumina, oxides of iron and manganese,	.063
Carbonate of lime,	.496
Magnesia,	.072
Sulphuric acid,	.047
Potash,	.140
Soda, (not estimated.)	
Silica,	.233
	1.321

The air-dried sub-soil lost 3.25 per cent. of *moisture* at 400°; dried at which temperature its *composition* is as follows, viz:

Organic and volatile matters,	3.229
Alumina,	4.345
Oxide of iron,	4.495
Carbonate of lime,	.197
Magnesia,	.289
Brown oxide of manganese,	.012
Phosphoric acid,	·109
Sulphuric acid,	.050
Potash,	.235
Soda,	.042
Sand and insoluble silicates,	86.720
Loss,	.277
	100 000

It will be seen, that this sub-soil contains more than twice as much carbonate of lime than the upper soil of the old field; it is also richer in potash and phosphoric acid. The proportion of sulphuric acid in it

is small, however, and although it might improve the fertility of the field somewhat to use the sub-soil plough, yet the addition of Plaster of Paris, and marl, or manures containing phosphates and calcareous matter, would be still more beneficial. The considerable proportion of alumina and oxide of iron of this sub-soil would also be beneficial in its admixture with the surface soil.

No. 587—MARL. *Labeled "Marl from the line between Bullitt and Spencer counties, Kentucky, in the Favosites maximus beds. Lower Silurian formation."*

In friable lumps of a grey-buff color, containing irregular nodules of porous limestone, and some portions of fossil shells; powder of a light buff color, slightly gritty under the teeth; effervesced strongly with hydrochloric acid.

The air-dried marl lost 2.55 per cent. of moisture, at 212° F.

Composition, dried at 212° F.—

Carbonate of lime,	41.740
Carbonate of magnesia,	1.088
Alumina, and oxides of iron and manganese,	5.480
Phosphoric acid,	.157
Sulphuric acid,	.066
Potash,	.573
Soda,	.152
Sand and insoluble silicates,	48.840
Water, organic matters, and loss,	1.904
	100.000

This calcareous marl, besides its large proportion of carbonate of lime, contains a considerable amount of potash, which would make it a very valuable addition to some of the light lands of Bullitt county, if the expense of hauling should not prove too great. As it has but a small relative proportion of sulphuric acid, and a moderate quantity of phosphoric acid, the addition of Plaster of Paris and super-phosphate of lime, or the latter alone, would make the application of this marl still more useful.

No. 588—MARL. *Labeled "Marl from the northeast part of Bullitt county, Kentucky.*

In irregular, soft, friable lumps, of a greenish-grey color. Gritty under the teeth Effervesces with acids.

The air-dried marl lost 3.15 per cent of moisture at 212° F.; and thus dried had the following *composition*, viz:

Carbonate of lime,	11.190
Carbonate of magnesia,	2.147
Alumina, and oxides of iron and manganese,	5.230
Phosphoric acid, (only a trace.)	
Sulphuric acid,	.066
Potash,	.308
Soda,	.055
Sand and insoluble silicates,	74.790
Water, organic matter and loss,	6.214
	100.000

This marl is not so rich in calcareous matter and potash as the preceding, yet it contains these in sufficient amount to make it a useful application to soils which are deficient in these materials. The almost total absence of phosphoric acid, and the small proportion of sulphuric acid which it contains, is a great draw-back on its value. It should, therefore, be mixed with acid phosphate of lime, (bones softened by means of sulphuric acid,) when it is used as a top-dressing to the land.

No. 589—LIMONITE. *Labeled "Iron ore from the knob at Bullitt's Lick. (Sub-carboniferous sandstone formation.) Bullitt county, Kentucky.*

Portion of a kidney-form mass; in concentric layers of a brown and brownish-yellow color; adhering to the tongue; powder of a brownish-yellow color.

Composition, dried at 212° F.—

Oxide of iron,	33.99	— 23.80 per cent. *Iron.*
Alumina,	1.58	
Brown oxide of manganese,	.48	
Lime, a trace.		
Magnesia,	.68	
Phosphoric acid, not estimated.		
Sulphur,	.35	
Potash,	.44	
Soda,	.23	
Silicious residue,	56.13	
Combined water,	6.75	
	100.63	

The air-dried ore lost .80 per cent. of moisture, at 212° F.

A very *silicious*, and rather *poor* ore of iron, which could perhaps be used with advantage to mix with richer ores.

CAMPBELL COUNTY.

No. 590—SOIL. *Labeled "Virgin soil, from Benj. Beall's land, Alexandria, Campbell county, Kentucky; primitive forest growth beech, walnut, hickory, sugar-tree, and large white oak. Lower Silurian formation."*

Dried soil of a light umber color. Washed with water it left 86.13 *per cent.* of sand, &c., of which 1.50 per cent. would not pass the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with a few of quartz.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up *nearly three grains of dark brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.000
Alumina, oxides of iron and manganese, and phosphates,	.713
Carbonate of lime,	.781
Magnesia,	.128
Sulphuric acid,	.050
Potash,	.079
Soda,	.037
Silica,	.086
	2.874

The air-dried soil lost 3.35 per cent. at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.614
Alumina,	3.084
Oxide of iron,	2.685
Carbonate of lime,	.274
Magnesia,	.474
Brown oxide of manganese,	.110
Phosphoric acid,	.245
Sulphuric acid,	.101
Potash,	.158
Soda,	.108
Sand and insoluble silicates,	86.730
Loss,	.417
	100.000

No. 591—SOIL. *Labeled "Soil from an old field, fifty years or more in cultivation, adjoining the "virgin soil," Benj. Beall's farm, Alexandria, Campbell county, Kentucky. Lower Silurian formation."*

The dried soil is of a dirty-buff color. Washed with water it left 78.10 per cent. of sand, &c., of which all but 0.90 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with a few of clear and milky quartz.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up 1.386 *grains of brownish extract,* dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.433
Alumina, oxides of iron and manganese, and phosphates,	.187
Carbonate of lime,	.403
Magnesia,	.032
Sulphuric acid,	.065
Potash,	.048
Soda,	.054
Silica,	.164
	1.386

The air-dried soil lost 1.925 per cent. of *moisture,* at 400° F.; dried at which temperature it had the following *composition,* viz:

Organic and volatile matters,	3.441
Alumina,	2.290
Oxide of iron,	2.110
Carbonate of lime,	.146
Magnesia,	.592
Brown oxide of manganese, a trace.	
Phosphoric acid,	.177
Sulphuric acid,	.119
Potash,	.111
Soda,	.053
Sand and insoluble silicates,	91.095
	100.134

No. 592—SUB-SOIL. *Labeled "Sub-soil from the old field fifty years or more in cultivation, Benj. Beall's farm, Alexandria, Campbell county, Kentucky. Lower Silurian formation."*

Dried sub-soil of a clearer buff color than the surface soil last described. Washed with water it left 65.40 per cent. of sand, &c., of which all but 0.77 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous and clear quartz particles.

One thousand grains of the air-dried sub-soil, digested for twenty days in water charged with carbonic acid, gave up *less than a grain of yellowish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.283
Alumina, oxides of iron and manganese, and phosphates,	.107
Carbonate of lime,	.097
Magnesia,	.069
Sulphuric acid,	.049
Potash,	.041
Soda,	.067
Silica,	.151
	0.864

The air-dried sub-soil lost 2.70 per cent. of *moisture* at 400°; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.826
Alumina,	3.740
Oxide of iron,	3.270
Carbonate of lime,	.072
Magnesia,	.430
Brown oxide of manganese,	.055
Phosphoric acid,	.146
Sulphuric acid,	.076
Potash,	.159
Soda,	.048
Sand and insoluble silicates,	88.845
Loss,	.333
	100.000

The difference between the composition of the virgin soil and that of the old field, as exhibited by the analyses, is striking and instructive. The sub-soil is not richer in potash than the *original* surface soil, and it contains less phosphoric acid, whilst it exhibits a remarkable deficiency of carbonate of lime. In the renovation of the old field, by

sub-soil plowing, lime or calcareous marl should also be abundantly applied.

CARROLL COUNTY.

No. 593—Soil. *Labeled "Virgin soil from Walton Craig's farm, half a mile from Ghent; bottom land; primitive forest growth, beech. Lower Silurian formation. Carroll county, Kentucky."*

The dried soil is of a dark-brownish-grey color. The coarse seive removed from it a few rounded particles, about the size of mustard seed, of ferruginous mineral and milky quartz or chert. Washed with water this soil left 86.46 per cent. of sand, &c., of which all except 2.85 per cent. passed through the finest bolting-cloth. This coarser portion of the soil is composed principally of rounded particles of hyaline quartz, with a few grains of soft ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly five grains of brownish extract*, dried at 212° F., of which the *composition* is as follows:

	Grains.
Organic and volatile matters,	1.317
Alumina, oxide of iron, and phosphates,	.980
Carbonate of lime,	1.730
Magnesia,	.183
Brown oxide of manganese,	.100
Sulphuric acid,	.085
Potash,	.228
Soda,	.030
Silica,	.237
	4.890

The air-dried soil lost 3.80 per cent. of moisture at 400° F., and has the following *composition*, viz:

Organic and volatile matters,	5.744
Alumina,	3.910
Oxide of iron,	3.455
Carbonate of lime,	.245
Magnesia,	.527
Brown oxide of manganese,	.222
Phosphoric acid,	.396
Sulphuric acid,	.054
Potash,	.312
Soda,	.022
Sand and insoluble silicates,	85.483
	100.370

No. 594—Soil. *Labeled "Soil from an old field; fifty years or more in cultivation, Walton Craig's farm, half a mile northwest of Ghent. Lower Silurian formation. Carroll county, Kentucky."*

The color of this dried soil is of a more yellowish tint than that of the preceding—approaching that of the sub-soil, next to be described.

The coarse seive removed from it a few rounded pebbles and gravel, from the size of a bean down to that of a mustard seed; consisting of sandstone, milky quartz, and other hard quartzose minerals, with some soft ferruginous gravel. Washed with water this soil left 84.76 per cent. of sand, &c., of which all but 2.23 per cent. was fine enough to pass through the finest bolting-cloth; this portion consists principally of clear yellowish and reddish rounded quartz particles with some ferruginous grains.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up more than four grains of *reddish-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.170
Alumina, oxides of iron and manganese, and phosphates,	.963
Carbonate of lime,	1.563
Magnesia,	.156
Sulphuric acid,	.145
Potash,	.096
Soda,	.042
Silica,	.207
	4.342

The air-dried soil lost 2.375 per cent. of *moisture* when dried at 400° F.; and its composition, thus dried, is as follows:

Organic and volatile matters,	3.618
Alumina,	2.820
Oxide of iron,	2.845
Carbonate of lime,	.170
Magnesia,	.340
Brown oxide of manganese,	.195
Phosphoric acid,	.203
Sulphuric acid,	.038
Potash,	.287
Soda,	.064
Sand and insoluble silicates,	89.921
	100.505

No. 595—SUB-SOIL. *Labeled "Sub-soil from the old field, fifty years or more in cultivation, Mr. Walton Craig's farm, half a mile north-west of Ghent, Carroll county, Kentucky. Lower Silurian formation.*

Color of the sub-soil of a more pure yellowish-brown tint than that of the preceding soil. The coarse seive removed from it a few rounded pebbles of chert, sandstone, und milky quartz, from the size of a coffee-tree bean to that of mustard seed. Washed with water this soil left 87.10 per cent. of sand, &c., of which all but 2.5 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted principally of rounded grains of hyaline quartz, with a few of yellow milky and reddish quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *more than two grains of light brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.490
Alumina, oxides of iron and manganese, and phosphates,	.297
Carbonate of lime,	.830
Magnesia,	.066
Sulphuric acid,	.050
Potash,	.056
Soda,	.030
Silica,	.200
	2.019

The air-dried sub-soil lost 2.30 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.814
Alumina,	2.470
Oxide of iron,	2.630
Carbonate of lime,	.280
Magnesia,	.300
Brown oxide of manganese,	.180
Phosphoric acid,	.227
Sulphuric acid,	.059
Potash,	.256
Soda,	.026
Sand and insoluble silicates,	90.515
Loss,	.243
	100.000

This must be quite a fertile soil. The deterioration caused by fifty years or more of cultivation of the "old field," is well exhibited in the analyses. The sub-soil is hardly equal, in its proportions of phosphoric acid and potash, to the original surface soil. Sub-soil ploughing, or trenching, bringing up the sub-soil to the surface would, therefore, only be beneficial to the very old and exhausted fields, except so far as the mechanical loosening of the sub-stratum would facilitate the growth of vegetables.

CRITTENDEN COUNTY.

No. 596—SUB-SOIL, OR EARTH. *Labeled "Upland, lying immediately above the upper intercalated limestone. Millstone grit formation. Crittenden county, Kentucky."*

The dried soil is of a buff color. Washed with water it left 83.9 per cent. of sand, &c., of which all but 0.53 per cent. was fine enough to pass through the finest bolting-cloth; this portion consisted of fragments of fossils, quartzose and ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up a little more than a grain of *light buff-colored extract,* which had the following *composition:*

Organic and volatile matters,	0.333
Alumina, oxides of iron and manganese, and phosphates,	.117
Carbonate of lime,	.173
Magnesia,	.086
Sulphuric acid,	.039
Potash,	.051
Soda,	.077
Silica,	.181
	1.057

The air-dried soil lost 3.415 per cent. of *moisture,* at 400° F., dried at which temperature it has the following *composition,* viz:

Organic and volatile matters,	4.695
Alumina,	5.070
Oxide of iron,	5.285
Carbonate of lime,	.050
Magnesia,	.606
Brown oxide of manganese, a trace.	
Phosphoric acid,	.106
Sulphuric acid,	.167
Potash,	.188

Soda,	.067
Sand and insoluble silicates,	83.548
Loss,	.218
	100.000

Although this lies immediately upon a limestone, the proportion of carbonate of lime in it is remarkably small. The application of lime to such land must always be beneficial. The oxide of manganese is also in quantity almost inappreciable.

DAVIESS COUNTY.

No. 597—SOIL. *Labeled "Soil which has never been in cultivation, from slope of ridge at Henry Dugan's farm, near the Coal Measures limestone; one of the best soils of Daviess county; forks of Panther; primitive forest growth, yellow poplar, much sugar-tree, black oak, hickory, sweet and black gum, elm, some beech, and black walnut."*

The dried soil is of a mouse-color. Washed with water, it left 82.3 per cent. of *sand*, &c., of which all but 1.6 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted principally of rounded ferruginous particles, with a few grains of hyaline quartz, and of a black substance like scoria.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up to it *nearly four and a half grains of brownish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.340
Alumina, oxide of iron, and phosphates,	.218
Carbonate of lime,	1.660
Magnesia,	.266
Brown oxide of manganese,	.497
Sulphuric acid,	.188
Potash,	.142
Soda,	.023
Silica,	.099
	4.433

The air-dried soil lost 4.20 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	6.972
Alumina,	1.360
Oxide of iron,	1.660
Carbonate of lime,	.536
Magnesia,	.358
Brown oxide of manganese,	.218
Phosphoric acid,	.177
Sulphuric acid,	.103
Potash,	.193
Soda,	.029
Sand and insoluble silicates, and loss,	89.394
	100.000

No. 598—SOIL. *Labeled "Soil from slope of ridge, at Henry Dugan's, near Coal-Measures limestone; in cultivation four years in tobacco, wheat, &c.; same primitive growth as preceding; forks of Panther, Daviess county, Kentucky."*

Color of the dried soil a little lighter than that of the preceding, and of a slight yellowish-tint. Washed with water it left 80.2 per cent. of sand, &c., of which all but 1.4 per cent. was fine enough to pass through the finest bolting-cloth; this portion was principally small rounded ferruginous particles with a few quartzose.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than three and *a half grains of light brownish-grey extract,* which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.800
Alumina, oxide of iron, and phosphates,	.168
Carbonate of lime,	1.798
Magnesia,	.233
Brown oxide of manganese,	.367
Sulphuric acid,	.090
Potash,	.083
Soda,	.042
Silica,	.139
	3.720

The air-dried soil lost 2.88 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	6.301
Alumina,	1.776
Oxide of iron,	2.380
Carbonate of lime,	.416
Magnesia,	.341
Brown oxide of manganese,	.038
Phosphoric acid,	.151
Sulphuric acid,	.098
Potash,	.158
Soda,	.027
Sand and insoluble silicates,	89.236
	100.919

No. 599—SUB-SOIL. *Labeled "Sub-soil, from the field in cultivation, Henry Dugan's land, near Coal Measures limestone, forks of Panther Daviess county, Kentucky."*

Color of the dried sub-soil dirty grey-buff; much lighter than that of the preceding soil. Washed with water this sub-soil left 75.9 per cent. of sand, &c., of which all but 0.9 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted of rounded ferruginous and quartzose particles, with a few of a dark colored substance like scoria.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *more than a grain and a half of brownish-grey extract*, which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.340
Alumina, oxide of iron and phosphates,	.068
Carbonate of lime,	.498
Magnesia,	.106
Brown oxide of manganese,	.239
Sulphuric acid,	.113
Potash,	.073
Soda,	.001
Silica,	.149
	1.587

The air-dried sub-soil lost 2.40 per cent. of *moisture* at 400° F.; and thus dried had the following composition:

Organic and volatile matters,	2.868
Alumina,	1.756
Oxide of iron,	2.520
Carbonate of lime,	.038
Magnesia,	.156
Brown oxide of manganese,	.174
Phosphoric acid,	.177
Sulphuric acid,	.068
Potash,	.097
Soda,	.015
Sand and insoluble silicates,	92.276
	100.145

The soil of the field which has been in cultivation only four years in tobacco and wheat shows a sensible diminution of organic matters, lime, magnesia, sulphuric and phosphoric acid, and the alkalies; is of a slightly lighter color than the virgin soil; gives less soluble extract to the water containing carbonic acid, (representing atmospheric water,) and holds less of hygrometric moisture; moreover, it contains a somewhat larger proportion of sand and insoluble silicates; the sub-soil of the old field is not as rich as the original surface soil.

ESTILL COUNTY.

No. 600—CARBONATE OF IRON. *Labeled "Iron ore, brought by Dr. E. L. Dudley from Sweet Lick knob, near Irvine, Estill county, Kentucky. Devonian formation."*

A nodule; the interior nucleus is a dark-grey fine-granular carbonate of iron; not adhering to the tongue; the exterior easily separates in dull-brown layers, which adhere to the tongue; powder of a mixture of the exterior and nucleus, of a brownish-yellow color.

Dried at 212° F., it lost 0.50 per cent. of *moisture*. Its composition, thus dried, is as follow, viz:

Oxide of iron,	52.60	= 42.72 per cent. of *Iron*.
Carbonate of iron,	13.64	
Carbonate of lime,	1.00	
Carbonate of magnesia,	3.96	
Carbonate of manganese,	1.18	
Alumina,	1.01	
Phosphoric acid,	0.37	
Sulphur	.13	
Potash,	.25	
Soda, a trace.		

Combined water, - -	5.70
Silex and insoluble silicates, -	20.78
	100.62

A very good ore of iron, which requires only the addition of limestone to make it smelt well in the high furnace.

No. 601—Mineral Water. *Labeled "White Sulphur water from Estill Springs, Irvine, Estill county, Kentucky."*

An opportunity has not yet been afforded for a complete *quantitative* analysis of the waters of the celebrated Estill mineral springs, at Irvine, but the waters of two of the springs were tested some years since, and the results will be given in this report.

Specific gravity of the "White Sulphur" water, - - 1.001

One thousand grains gave, by evaporation, about 0.9 of a grain of saline matter, dried at 212° F. The water was found to contain

Sulphuretted hydrogen gas;
Carbonic acid gas;
Bi-carbonate of lime;
Bi-carbonate of magnesia;
Bi-carbonate of iron, a trace;
Bi-carbonate of soda;
Sulphate of lime;
Sulphate of magnesia;
Sulphate of soda;
Chloride of sodium;
And probably sulphate of potash,
Or chloride of potassium, with other chlorides. Whether iodine or bromine is to be found in this can only be ascertained by operating on large quantities of the water, evaporated to a small amount.

No. 602—Mineral Water. *Labeled "Red Sulphur water from Estill Springs, Irvine, Estill county, Kentucky."*

The specific gravity of this water is - - - - 1.0002

One thousand grains gave only 0.4 of a grain of saline matter on evaporation to dryness.

This water is weaker than the preceding, but contains a larger proportion of chlorides.

It contains the same gases, viz: Sulphuretted hydrogen and carbonic acid; also bi-carbonates of lime, magnesia, and soda, in notable

proportions, with a trace of bi-carbonate of iron, probably more than is contained in the "White Sulphur."

It also contains sulphates of lime, magnesia, and soda, and probably of potash, with chlorides of sodium, calcium, and magnesium.

It is remarkable, in regard to these waters, as well as those of the Olympian Springs, and of several other springs of the state, that bi-carbonate of soda appears to exist, in the recent waters, in solution with bi-carbonates of lime, magnesia, and iron, even in the presence of a trace of sulphuretted hydrogen. These substances being all held in harmonious solution by the excess of carbonic acid present; when that gas escapes, however—as when the water is allowed to stand exposed to the air, or is boiled—the earthy carbonates fall down as insoluble precipitates, along with the iron which is thrown down as peroxide, or, in the presence of alkaline and earthy carbonates and sulphuretted hydrogen, partly as sulphuret of iron. It is probable that the "red" and dark colors noticed in the sediments from sulphur waters, which cause them to be denominated *red sulphur* or *black sulphur*, as the case may be, are due to the presence of iron, in less or greater quantities, whilst the sediment of the white sulphur, so-called, contains little or none of this substance.

FRANKLIN COUNTY.

No. 603—SOIL. *Labeled "Soil from an unproductive spot, where a kiln of lime was formerly burnt, about thirty years ago, on Mr. Clarke's farm, two miles from Frankfort. Blue limestone formation. Franklin county, Kentucky."*

Some fragments of limestone were found in this soil. The color of the dried soil is dirty-grey-buff. Washed with water it left 67.7 per cent. of grey-buff sand, &c., of which all but 6.3 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous and quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of brownish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.600
Alumina, oxide of iron and phosphates,	.068
Carbonate of lime,	3.898
Magnesia,	.126
Brown oxide of manganese, a trace.	
Sulphuric acid,	.185
Potash,	.057
Soda,	.037
Silica,	.099
	5.070

The air-dried soil lost 3.44 per cent. of *moisture* at 400° F.; dried at which temperature it was found to have the following *composition :*

Organic and volatile matters,	4.722
Alumina,	2.156
Oxide of iron,	5.120
Carbonate of lime,	1.490
Magnesia,	.832
Brown oxide of manganese,	.038
Phosphoric acid,	.304
Sulphuric acid,	.055
Potash,	.212
Soda,	.065
Sand and insoluble silicates,	84.974
Loss,	.032
	100.000

There is nothing in the *composition* of this soil which would account for its unproductiveness, all the essential ingredients being in good and sufficient quantities, except perhaps *sulphuric acid,* which is in rather less than the average quantity found in good soils, and *oxide of manganese,* which is decidedly deficient.

Notwithstanding the observations of that praise-worthy German Agricultural Chemist, Sprengel, on the influence exerted by oxide of manganese on the growth of plants, we know too little of its action on organic beings, vegetable and animal, to decide that its absence from the present soil is the cause of its sterility. The probability is, however, that some local accidental cause—as for instance, the escape of carbonic acid gas through some crevice in the rocks beneath the spot, and up through the soil—may be the reason why vegetables do not thrive there. The same remarks wo ld apply to the soil next to be described.

No. 604—SOIL. *Labeled "Soil from a "sick spot," on the blue limestone formation, near the Kentucky river, two miles from Frankfort, Franklin county, Kentucky. From limited spots where the soil is entirely bare of vegetation, and the grass beyond, for twenty paces, is yellow and sickly."*

The soil was found to contain loose fragments of porous limestone. (See number 605.)

The dried soil is of a dirty reddish-grey-brown color. Washed with water it left 68.4 per cent. of sand, &c., of which all but 8.4 per cent. was fine enough to pass through the finest bolting-cloth. This portion consists of rounded ferruginous and quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly six grains of brownish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.340
Alumina, and oxide of iron and phosphates,	.093
Carbonate of lime,	4.838
Magnesia,	.110
Brown oxide of manganese,	.029
Sulphuric acid,	.167
Potash,	.057
Soda,	.026
Silica,	.118
Loss,	.087
	5.860

The air-dried soil lost 3.92 per cent. of *moisture* at 400° F.; dried at which temperature it was found to have the following *composition:*

Organic and volatile matters,	5.911
Alumina,	2.550
Oxide of iron,	4.380
Carbonate of lime,	1.470
Magnesia,	.826
Brown oxide of manganese,	.376
Phosphoric acid,	.433
Sulphuric acid,	.095
Potash,	.251
Soda,	.007
Sand and insoluble silicates,	83.936
	100.235

This has the composition of a fertile soil, and its unproductiveness must doubtless be attributed to local and accidental circumstances, as stated in connection with the analysis of the next preceding soil, No. 603.

No. 605—LIMESTONE. *Labeled "Porous limestone, found in the soil from the "sick spot," No. 604. Blue limestone of the Lower Silurian formation. Franklin county, Kentucky."*

Pores, in some places, lined with red oxide of iron; structure crystalline granular; light-grey color in the interior; dirty-buff on the exterior; contains fossil shells and coral; powder nearly white.

Dried at 212° F. it lost 0.30 per cent. of moisture.

Composition, dried at 212° F.—

Carbonate of lime, - - -	95.15	= 53.39 of *Lime*.
Carbonate of magnesia, - -	2.55	
Alumina, and oxides of iron and manganese, - - - -	.87	
Phosphoric acid, - - -	.08	
Sulphuric acid, - - -	.85	
Potash, - - - - - -	.23	
Soda, - - - - - -	.23	
Silex and insoluble silicates, -	.58	
	100.54	

A pretty pure limestone, similar in composition to other specimens of *blue limestone* which have been examined, which contains many of the elements of vegetable nourishment, and hence exerts a beneficial, and not an injurious, effect upon the soil with which it is in contact.

No. 606—SOIL. *Labeled " Virgin soil, from a new field for the first time in cultivation in a crop of corn, Alexander Julian's farm, four miles from Frankfort, Franklin county, Kentucky. Primitive forest growth, principally sugar-tree and mulberry. Lower Silurian formation, nearest to the encrinital member of the blue limestone."*

Dried soil of a greyish-brown color. The coarse sieve removed from it a few rounded pebbles of yellowish quartz. Washed with water this soil left 81.9 per cent. of sand, &c., of which all but 4.03 per cent. was fine enough to pass through the finest bolting-cloth. This

portion consisted of clear grains of quartz, more or less rounded, with some ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly two and a half grains of light-brown extract,* having the following *composition,* viz:

	Grains.
Organic and volatile matters, - - - - - - -	0.580
Alumina, oxides of iron and manganese, and phosphates, - -	.143
Carbonate of lime, - - - - - - - - - -	.997
Magnesia, - - - - - - - - - -	.130
Sulphuric acid, - - - - - - - - - -	.060
Potash, - - - - - - - - - -	.130
Soda, - - - - - - - - - -	.080
Silica, - - - - - - - - - -	.214
Loss, - - - - - - - - - - -	.046
	2.380

The air-dried soil lost 3.79 per cent. of *moisture,* at 400° F., dried at which temperature it has the following *composition* :

Organic and volatile matters, - - - - - - -	5.935
Alumina, - - - - - - - - - -	2.840
Oxide of iron, - - - - - - - - - -	2.370
Carbonate of lime, - - - - - - - - -	.295
Magnesia, - - - - - - - - - - -	.296
Brown oxide of manganese, - - - - - - -	.220
Phosphoric acid, - - - - - - - - -	.182
Sulphuric acid, - - - - - - - - - -	.084
Potash, - - - - - - - - - - -	.198
Soda, - - - - - - - - - - -	.040
Sand and insoluble silicates, - - - - - - -	87.280
Loss, - - - - - - - - - - -	.260
	100.000

No. 607—SOIL. *Labled "The same soil, from an adjoining old field, forty years in cultivation; chiefly in corn, oats, wheat, and rye; for the last ten years occasionally in clover; usually pastured down; Alexander Julian's farm, four miles from Frankfort, Franklin county, Kentucky."*

The color of this soil is intermediate between that of the virgin soil and the sub-soil. The coarse seive removed from it some milky quartz pebbles, and some smaller fragments of ferruginous mineral.

Washed with water this soil left 73.83 per cent. of sand, &c., of which all but 9.20 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded quartz grains, mixed with a few ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than a grain and a half of light brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.240
Alumina, oxides of iron and manganese, and phosphates,	.163
Carbonate of lime,	.697
Magnesia,	.056
Sulphuric acid,	.078
Potash,	.079
Soda,	.012
Silica,	.200
	1.525

The air-dried sub-soil lost 4.125 per cent. of moisture at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	3.911
Alumina,	3.220
Oxide of iron,	4.290
Carbonate of lime,	.305
Magnesia,	.271
Brown oxide of manganese,	.320
Phosphoric acid,	.350
Sulphuric acid,	.050
Potash,	.200
Soda,	.017
Sand and insoluble silicates,	87.280
	100.214

No. 608—SUB-SOIL. *Labeled "Sub-soil from the same old field, (as the preceding,) Alexander Julian's farm, four miles from Frankfort, Franklin county, Kentucky."*

Dried soil of a dark dirty-buff color. Some small rounded pebbles of yellowish milky quartz, and smaller particles of ferruginous mineral, were sifted out of it with the coarse seive. Washed with water it left 63.33 per cent. of sand, &c., of which all but 3.83 per cent. was fine

enough to go through the finest bolting-cloth. This coarser portion consisted of clear and colored grains of quartz, more or less rounded, with some of ferruginous mineral.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *nearly a grain and a half of light brown extract,* which had the following *composition,* dried at 212° F., viz:

	Grains.
Organic and volatile matters,	0.282
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime.	.614
Magnesia,	.053
Sulphuric acid,	.136
Potash,	.047
Soda,	.010
Silica,	.231
	1.436

The air-dried sub-soil lost 4.815 per cent. of moisture, at 400° F., dried at which temperature it had the following *composition:*

Organic and volatile matters,	3.405
Alumina,	4.095
Oxide of iron,	4.825
Carbonate of lime,	.246
Magnesia,	.450
Brown oxide of manganese,	.335
Phosphoric acid,	.359
Sulphuric acid,	.081
Potash,	.202
Soda,	.029
Sand and insoluble silicates,	85.810
Loss,	.163
	100.000

The results presented by the analyses of the preceding soils are somewhat anomalous in relation to the proportions of potash and phosphoric acid, of which the former appears to be about the same in that of the old field as is found in the virgin soil, and the latter even in larger proportion. If no error has been committed in the labeling, or the labels have not been interchanged, as sometimes inadvertantly happens, (one or two cases of which have been corrected by means of the analyses, as previously stated,) the anomaly may be explained by the sup-

position that some of the sub-soil, which has been brought to the surface of the old field by the plough, has been accidentally taken for analysis. By reference to the analysis of the sub-soil a striking similarity will be observed, in regard to the ingredients mentioned, in this and the surface soil of the old field. Not having taken measures to secure new specimens of Mr. Julian's soils for analysis, to verify these conjectures, we let them go, for the present, for as much as they are worth.

No. 609—LIMONITE (IMPURE.) *Labeled "Iron ore from Mr. Alexander Julian's farm, Franklin county, Kentucky."*

A friable cellular limonite; mottled; dark-brown and yellowish, and whitish; powder of a brown color. Dried at 212° F. it lost 6.20 per cent. of *moisture:*

Composition, dried at 212° F.—

Oxide of lime,	26.69	= 18.69 per cent. of *Iron*.
Alumina,	7.55	
Lime, a small trace.		
Brown oxide of manganese,	3.68	
Magnesia,	1.15	
Phosphoric acid,	.63	
Sulphur,	.05	
Potash,	.63	
Soda, a small trace.		
Combined water,	7.50	
Silex and insoluble silicates,	52.68	
	100.56	

Rather too poor for profitable smelting by itself, but it might be used in mixture with calcareous ores, or with ores which contained too large a per centage of iron to furnish materials for *cinder*.

No. 610—SANDSTONE. *Labeled "Soft Green Rock, Frankfort, Franklin county, Kentucky. Lower Silurian."*

Rounded fragments of a soft granular rock, of a bluish-green color; adheres strongly to the tongue; powder greenish-white. Dried at 212° F., it lost 4. per cent. of moisture.

Composition, dried at 212° F.—

Alumina, and oxides of iron and manganese,	9.47	
Carbonate of lime,	.99	
Carbonate of magnesia,	2.44	
Phosphoric acid,	.18	
Sulphuric acid,	2.60	= 1.03 of sulphur.
Potash,	2.37	
Soda,	.13	
Silex and insoluble silicates,	80.68	
Water and loss,	1.14	
	100.000	

No. 611—UNDER-CLAY. *Labeled "Clay, one and a half to two feet under the surface soil, waters of Benson, near Hardinsburgh, Franklin county, Kentucky."*

Dried clay of dark greyish-buff color. The coarse seive removed from it some rounded fragments of ferruginous sandstone. Washed thoroughly with water it left 48.10 per cent. of fine sand, of which all but 0.86 per cent. passed through the finest bolting-cloth; this portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried clay, digested for a month in water containing carbonic acid, gave up *about a grain of nearly white extract*, dried at 212 F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.200
Alumina, oxides of iron and manganese, and phosphates,	.055
Carbonate of lime,	.214
Magnesia,	.028
Sulphuric acid,	.022
Potash,	.073
Soda,	.079
Silica,	.298
Loss,	.031
	1.000

The air-dried clay lost 4.40 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition:*

	Grains.
Organic and volatile matters,	4.205
Alumina,	6.390
Oxide of iron,	7.240
Carbonate of lime,	.097
Magnesia,	.781
Brown oxide of manganese,	.145
Phosphoric acid,	.182
Sulphuric acid,	.033
Potash,	.444
Soda,	.032
Sand and insoluble silicates,	80.580
	100.129

If this clay contained more carbonate of lime and phosphoric acid, these, with its considerable proportion of potash might make it a valuable application to exhausted land; as it is, it is not likely to prove very valuable for this purpose.

No. 612—Soil. *Labeled "Virgin soil from woodland pasture on Robt. W. Scott's farm, five miles from Frankfort, near the Versailles and Frankfort turnpike, and the Lexington and Frankfort railroad; primitive forest growth, sugar-tree, white, red and black oak, black walnut, mulberry and honey locust. Lower Silurian formation. Franklin county, Kentucky."*

The dried soil is of a light-umber color. It contained a little soft iron gravel. Washed with water it left 82.90 per cent. of sand, &c., of which all but 6.10 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up *about four grains of reddish-brown extract,* dried at 212°, F., which had the following *composition:*

Organic and volatile matters,	0.692
Alumina, oxides of iron and manganese, and phosphates,	.688
Carbonate of lime,	2.113
Magnesia,	.208
Sulphuric acid,	.028
Potash,	.096
Soda,	.144
Silica,	.114
	4.083

The air-dried soil lost 5.625 per cent. of moisture at 400°, dried at which temperature it had the following *composition:*

Organic and volatile matters,	7.072
Alumina,	3.890
Oxide of iron,	4.785
Carbonate of lime,	.495
Magnesia,	.607
Brown oxide of manganese,	.272
Phosphoric acid,	.404
Sulphuric acid,	.153
Potash,	.215
Soda,	.084
Sand and insoluble silicates,	82.270
	100.247

No. 613—Soil. *Labeled "Soil from an adjoining field, forty to fifty years in cultivation; rotation of crops and grasses, without manure. Robt. W. Scott's farm, near Frankfort, Franklin county, Kentucky."*

Color of the dried soil slightly lighter and more yellowish than that of the preceding. It contained about one-twentieth of its weight of soft iron gravel. Washed with water it left 67.37 per cent. of sand, &c, of which all but 6.96 per cent. was fine enough to go through the fine bolting-cloth. This portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in the water containing carbonic acid, gave up to it about *three grains of light-brown extract,* dried at 212° F., which had the following *composition:*

	Grains.
Organic and volatile matters,	0.783
Alumina, oxides of iron and manganese, and phosphates,	.463
Carbonate of lime,	1.280
Magnesia,	.158
Sulphuric acid,	.039
Potash,	.094
Soda,	.081
Silica,	.139
	3.037

The air-dried soil lost 4.25 per cent. of *moisture* at 400°, F.; dried at which temperature it had the following *composition:*

	Grains.
Organic and volatile matters,	6.292
Alumina,	3.975
Oxide of iron,	4.045
Carbonate of lime,	.430
Magnesia,	.519
Brown oxide of manganese,	.197
Phosphoric acid,	.305
Sulphuric acid,	.093
Potash,	.206
Soda,	.054
Sand and insoluble silicates,	84.120
	100.236

No. 614—SUB-SOIL. *Labeled "Sub-soil from the old field, Robt. W. Scott's farm, near Frankfort, Franklin county, Kentucky."*

The air-dried sub-soil is of a dirty-buff color. It contained about one-ninth of its weight of soft iron gravel. Washed with water it left about 70.90 per cent. of sand, &c., of which all but 5.40 per cent. was fine enough to go through the finest bolting-cloth. This portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for twenty days in water containing carbonic acid, gave up *less than a grain of brownish-grey extract*, dried at 212° F., which had the following *composition*, viz:

Organic and volatile matters,	0.392
Alumina, oxides of iron and manganese, and phosphates,	.055
Carbonate of lime,	.163
Magnesia,	.050
Sulphuric acid,	.028
Potash,	.046
Soda,	.057
Silica,	.106
	0.897

The air-dried sub-soil lost 4.475 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition:*

	Grains.
Organic and volatile matters,	3.611
Alumina,	5.740
Oxide of iron,	7.085
Carbonate of lime,	.445
Magnesia,	.383
Brown oxide of manganese,	.222
Phosphoric acid,	.316
Sulphuric acid,	.101
Potash,	.173
Soda,	.048
Sand and insoluble silicates,	82.450
	100.574

By comparing the above analyses it will be seen that there has been a marked change produced in the composition of the soil of the old field, by forty to fifty years cultivation, and that all the materials essential to the constitution of vegetables have been diminished in quantity. Taking for example the phosphoric acid, which is in the proportion of 0.404 per cent. in the virgin soil, and of 0.305 in that of the old field; or, calculating three millions of pounds of soil to the acre to the depth of one foot,

The *phosphoric acid* in the virgin soil is equal to	12,120 lbs.
The *phosphoric acid* in the old field only equal to	9,150
The quantity removed from the acre by cultivation, is	2,970 lbs.

The *potash* exhibits a comparatively smaller decrease, probably for the reason that the crops have been most frequently fed to cattle on the ground where they are grown, as this is a very common practice in this grazing country, and is well calculated to prevent much loss of the alkalies of the soil.

The *potash* in the virgin soil 0.215 per cent., is	6,450 lbs.	to the acre.
That in the soil of the old field 0.206 per cent.,	6,180	
Amount removed by cultivation,	270 lbs.	

The sub-soil does not appear to be as rich as the original surface soil; at all events it is not richer.

No. 615—LIMESTONE. *Labeled "Limestone under Robt. W. Scott's land, near Frankfort, Franklin county, Kentucky. Blue limestone of the Lower Silurian formation."*

A bluish-grey limestone, with blotches of yellowish; full of fossil shells, chætetes, &c., &c.

Composition, dried at 212° F.—

Carbonate of lime,	95.380	= 53.522 per cent. of *Lime*.
Carbonate of magnesia,	1.510	
Alumina, and oxides of iron and manganese,	.769	
Phosphoric acid,	.311	
Sulphuric acid,	.579	
Potash,	.108	
Soda,	.003	
Silex and insoluble silicates,	2.080	
	100.740	

This limestone, which is the sub-stratum of the three preceding soils, is of a composition to renovate the soil above, if, as is generally the case with this kind of limestone, it is easily disintegrated under the action of air and moisture.

FAYETTE COUNTY.

No. 616—LIMESTONE. *Labeled "Magnesian limestone from Harris' quarry, on Elk Lick, about one mile below Clay's ferry, and about a mile and a half, in a straight course, from Grimes' quarry, on the Kentucky river."*

Supposed to be of the same bed as Grimes'—See Nos. 511, 512 and 513, of the preceding volume—bed about five and a half to six feet thick; and lying about one hundred to a hundred and fifty feet above low water on the Kentucky river, as stated by Mr. Harris, General appearance of the limestone like that from Grimes' quarry. Two specimens were examined, marked A and B; one brought by Mr. Julius Adams, labeled A, and the other by Mr. Harris, proprietor of the quarry, marked B. The latter specimen was slightly lighter colored than the former.

Composition, dried at 212° F.—

	Specimen A.	*Specimen B.*
Specific gravity,	2.728	2.7678
Carbonate of lime,	59.88	64.40
Carbonate of magnesia,	37.05	33.90
Alumina, oxides of iron and manganese, and phosphates,	1.38	.95
Potash,	.61	not determ'd.
Soda,	.42	
Silex and insoluble silicates,	2.68	2.00
	102.02	101.25

Comparative experiments were made with the magnesian limestones from Grimes' and Harris' quarries, and some fine-grained pure white Italian statuary marble from the marble yard in the city of Lexington. Each specimen was dressed and rubbed down, as accurately as possible to the form of a parallelopipedon, one inch and five-eighths long, five-eighths of an inch wide, and five-sixteenths of an inch thick. These blocks were thoroughly dried for eight hours, at the temperature of the boiling point of water; they then were found to weigh as follows:

No. 1, from Grimes' quarry, weighed 43.0860 grammes.
No. 2, from Harris' quarry, weighed 45.2135 grammes.
No. 3, Italian statuary marble, weighed 47.1640 grammes.

The blocks were then immersed in pure water for twenty-four hours, the water being kept hot, and for much of that time at a boiling temperature. They were then taken out and wiped as dry as possible with bibulous paper, and again weighed, with the following results, viz:

No. 1, Grimes', weighed 44.7450 grammes.
No. 2, Harris', weighed 46.1185 grammes.
No. 3, Italian marble, weighed 47.2100 grammes.

Thus:

No. 1 had absorbed 1.6590 grammes, or 3.85404 per cent. of water.
No. 2 had absorbed 0.9050 grammes, or 2.00161 per cent. of water.
No. 3 had absorbed 0.0460 grammes, or 0.09753 per cent. of water.

On allowing the blocks to remain, freely exposed to the dry air, for half an hour, and weighing again,

No. 1 was found to have lost all the absorbed water except 1.3570 grammes.
No. 2 was found to have lost all the absorbed water except 0.6125 gramme.
No. 3 was found to have lost all the absorbed water except 0.0050 gramme.

After an hour's exposure to the air,

No. 1 still retained, of the absorbed water, 1.1840 grammes.
No. 2 still retained, of the absorbed water, 0.4565 gramme.
No. 3 still retained, of the absorbed water, 0.0020 gramme.

After twelve hours exposure to the air the Italian marble weighed 47.156 grammes, or 0.008 gramme less than before immersion in the water, so that it had lost some soluble matter in the water.

The Harris' marble still exhibited an excess over the original weight, (dried at 212°,) of 0.012 grammes, and the Grimes' of 0.839 grammes.

The several blocks were then again dried thoroughly at the boiling temperature of water, and it was found that they each had lost weight

probably by the solution in the water of some soluble matter from the stone, or the separation of loose minute particles, which may have been lodged on the surfaces.

No. 1, Grimes', had lost 0.0095 gramme.

No. 2, Harris', had lost 0.0155 gramme.

No. 3, Italian marble, had lost 0.0130 gramme.

Of course, when we make a compensation for this diminution of weight of the several blocks, after digestion in the water, some difference will be made in the figures representing the relative absorptive power in regard to water, of the three specimens; but yet it is evident, that so far as this test is concerned, the Italian marble exhibits by far the least power of absorbing water, and the Harris' rock less than that from Grimes' quarry. It is believed, however, from the great similarity of composition, and general structure of the limestones from Grimes' and Harris' quarries, that if *similar specimens* be taken from the two they would exhibit nearly corresponding results in experiments like the above described. The cause of the apparent difference in the above experiments is doubtless to be found, not in any natural difference in the nature of the limestones, but in the fact that the specimen from Harris' quarry was probably from near the weather-worn surface of the rock, the pores of which had been partly closed by the action of the atmospheric water, which, by dissolving a small quantity of the carbonate of lime, by means of the carbonic acid which it always contains, and leaving it deposited again on drying, had gradually filled up the interstices between the grains of the limestone, and thus diminished its power of absorbing water. The specimen from Grimes' quarry was from the interior of the bed.

A building stone which absorbs and retains much water is not usually a *durable* material, in regions where it is subject to the action of frost, and the more it absorbs of that fluid the greater is the danger of its speedy disintegration; for the reason that as water always expands, with an immense and uncontrollable force, when it freezes—increasing in volume one-eleventh of its bulk—the more water there is between the particles of the stone the greater is the danger of its disintegration by freezing.

It is to be remarked, however, that the relative power of absorbing water, of a building material, does not, in all cases, seem to measure its relative liability to disintegration under the action of frost, as may be

seen in the familiar examples of the Italian marble and the *well-burnt* brick. The latter having a much greater absorptive power than the former; while the ancient monuments of Europe and Asia demonstrate that nothing exceeds in durability the well-burnt clay.

The application of a solution of *soluble glass* to the surface of this magnesian building stone, according to the process of Fuchs, would fill up its pores and greatly increase its durability, whilst it would also probably prevent or diminish the dark discoloration which appears on the exterior after it has been exposed for some time to the atmosphere, which is no doubt occasioned by the penetration of water—it leaving its impurities on the surface.

No. 617—Fossil Chætetes Lycoperdon, *from the blue limestone of the Lower Silurian formation. Cut on the Henry's mill turnpike; Big Hill, near Lexington, Fayette county, Ky.*

A pure, selected piece of this fossil coral of the blue limestone, was submitted to analysis, to ascertain what elements it contributed to the general composition of the rock, especially in view of its agricultural relationships.

Composition, dried at 212° F.—

Carbonate of lime,	97.820
Carbonate of magnesia,	.839
Alumina, and oxides of iron and manganese,	.480
Phosphoric acid,	.118
Sulphuric acid,	.235
Potash,	.166
Soda,	.020
Silex and insoluble silicates,	.527
	100.205

Except that it contains less silicious matter it does not differ much in composition from the blue limestone itself—containing, as that does, all the mineral elements necessary to vegetable developement.

No. 618—Mineral Water. *Sulphur water from the new bored well at Montmollin's mill, on the Elkhorn branch, Lexington, Fayette county, Ky.*

This is an agreeable, weak, saline sulphur water, containing
Sulphuretted hydrogen gas;
Carbonic acid gas;

Bi-carbonates of lime and magnesia;

Sulphates of lime, magnesia, and probably of potash and soda, with a considerable proportion of chloride of sodium.

It was tested by the writer about two years ago, and found to yield on evaporation *about one grain of dry saline matters* to the thousand grains of water. It was thought, at the time, that it also contained a trace of some phosphate. Complete analysis might show in it small quantities of iodine or bromine.

GALLATIN COUNTY.

No. 619—Soil. *Labeled "Blue limestone soil, from a field thirty to forty years in cultivation, now in broom corn, near Big Lick creek, Gallatin county, Ky. No woodland near."*

Dried soil of a greyish or umber-brown color. The coarse seive removed from it a small quantity of rounded particles of quartz and ferruginous mineral, rather larger than mustard seed. Washed with water this soil left 83.93 per cent. of sand, &c., of which 16.7 per cent. was too coarse to pass through fine bolting cloth. This consisted principally of rounded particles of ferruginous mineral, with a few of quartz. The apparent excess of this sand, &c., washed out by water, over the amount of sand and insoluble silicates, as given by the full analysis, is owing to the fact that the ferruginous mineral is mainly soluble in the hydrochloric acid, in which the soil was digested in the analysis.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly three grains of light buff-grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.530
Alumina, oxides of iron and manganese, and phosphates,	.363
Carbonate of lime,	1.530
Magnesia,	.090
Sulphuric acid,	.039
Potash,	.073
Soda,	.047
Silica,	.236
	2.908

The air-dried soil lost 5.575 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition*, viz:

Organic and volatile matters,	7.005
Alumina,	5.965
Oxide of iron,	6.035
Carbonate of lime,	.920
Magnesia,	.768
Brown oxide of manganese,	.320
Phosphoric acid,	.360
Sulphuric acid,	.114
Potash,	.484
Soda,	.013
Sand and insoluble silicates,	77.770
Loss,	.246
	100.000

This still has the composition of a very rich and fertile soil. It does not yield as much *soluble extract* to water charged with carbonic acid as the virgin soils generally on this formation—an evidence that it does not contain as large a proportion of *immediately available, or soluble*, nourishment for plants as they do. Its large proportions of potash, phosphoric and sulphuric acid, of lime, magnesia, and oxide of manganese, as well as of alumina, and oxide of iron, make it one of the superior soils of Kentucky. The sub-soil next to be described does not differ much from it in composition.

No. 620—Sub-soil. *Labeled "Sub-soil from the same field, thirty to forty years in cultivation, near Big Lick creek, Gallatin county, Kentucky."*

Color of the dried sub-soil slightly lighter than that of the preceding. It also contains particles of ferruginous mineral too large to pass through the coarse seive. Washed with water it left 79.83 per cent. of sand, &c., of which all but 17.96 per cent. passed through the finest bolting cloth; this portion is principally composed of rounded ferruginous particles, with very few of quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *nearly three and a half grains of grey-buff extract*, dried at 212° F., which had the following *composition*, viz:

	Grains,
Organic and volatile matters,	0.570
Alumina, oxides of iron and manganese, and phosphates,	.530
Carbonate of lime,	1.850
Magnesia,	.099
Sulphuric acid,	.022
Potash,	.053
Soda,	.053
Silica,	.264
	3.441

The air-dried sub-soil lost 6.00 per cent. of *moisture*, at 400° F.; dried at which temperature it had the following *composition*:

Organic and volatile matters,	6.543
Alumina,	5.715
Oxide of iron,	6.170
Carbonate of lime,	.970
Magnesia,	.818
Brown oxide of manganese,	.595
Phosphoric acid,	.310
Sulphuric acid,	.079
Potash,	.354
Soda,	.021
Sand and insoluble silicates,	77.855
Loss,	.570
	100.000

It is somewhat of an anomaly that this sub-soil contains more organic and volatile matters, and less phosphoric acid, sulphuric acid, and potash, than the surface soil, and that it gives more of soluble matter to the water containing carbonic acid than that.

GARRARD COUNTY.

No. 621—SOIL. *Labeled "Virgin soil, from woods pasture, on J. S. Hoskins' farm, forks of the road; some of the best soil in the county. Lower Silurian formation. Garrard county, Kentucky."*

Dried soil of a grey-brown color. The coarse seive removed a few small, irregular, cherty, fragments, a portion of an encrinital stem, and some soft ferruginous particles. Washed with water this soil left 73.77 per cent. of sand, &c., of which all but 4.63 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion

consisted principally of rounded particles of soft ferruginous mineral, with a few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than seven and a half grains of chestnut colored extract,* dried at 212°, which had the following *composition:*

Organic and volatile matters,	1.230
Alumina, oxides of iron and manganese, and phosphates,	.930
Carbonate of lime,	4.413
Magnesia,	.323
Sulphuric acid,	.041
Potash,	.386
Soda,	.080
Silica,	.231
	7.634

The air-dried soil lost 5.825 per cent. of *moisture* at 400° F.; at which temperature it has the following *composition:*

Organic and volatile matters,	8.548
Alumina,	6.190
Oxide of iron,	3.920
Carbonate of lime,	1.910
Magnesia,	.763
Brown oxide of manganese,	.520
Phosphoric acid,	.559
Sulphuric acid,	.128
Potash,	.393
Soda,	.081
Sand and insoluble silicates,	77.380
	100.000

No. 622—Soil. *Labeled "Same soil (as the preceding,) from the oldest field in Garrard county; sixty to seventy years in cultivation; overlying cherty beds of blue limestone; Lower Silurian formation. J. S. Hoskins' farm. Garrard county, Kentucky."*

Color of the dried soil a little lighter and more yellowish than that of the preceding. It contains a few small rounded fragments of soft ferruginous sandstone. Washed with water it left 81.46 per cent. of sand, &c., of which all but 7.83 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded particles of ferruginous mineral, with very few quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than four and a half grains of light chestnut-brown extract*, dried at 212° F., which had the following *composition:*

	Grains.
Organic and volatile matters,	0.883
Alumina, oxides of iron and manganese, and phosphates,	.913
Carbonate of lime,	2.117
Magnesia,	.140
Sulphuric acid,	.022
Potash,	.152
Soda,	.135
Silica,	.224
	4.586

The air-dried soil lost 4.55 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.238
Alumina,	7.805
Oxide of iron,	5.165
Carbonate of lime,	3.270
Magnesia,	1.358
Brown oxide of manganese,	.649
Phosphoric acid,	.484
Sulphuric acid,	.059
Potash,	.386
Soda,	.025
Sand and insoluble silicates,	75.570
	100.000

These are both examples of good blue limestone, or "blue-grass" soil—the soil of the old field being still nearly as rich as the original soil in the neighborhood, notwithstanding the long period during which it has been in cultivation.

No. 623—SUB-SOIL. *Labeled "Sub-soil from J. S. Hoskins' old field, sixty to seventy years in cultivation. Lower Silurian formation. Garrard county, Kentucky."*

Color of this sub-soil still more yellowish and lighter than the preceding. Washed with water it left 83.9 per cent. of sand, &c., of which all but 12.96 per cent. passed through the finest bolting-cloth. This

coarser portion is principally composed of ferruginous and cherty rounded particles, with very few of quartzose mineral.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *more than three grains of l'ght-brown extract*, dried at 212° F.; which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.600
Alumina, oxides of iron and manganese, and phosphates,	.547
Carbonate of lime,	1.580
Magnesia,	.090
Sulphuric acid,	.025
Potash,	.049
Soda,	.038
Silica,	.257
	3.186

The air-dried sub-soil lost 4.95 per cent of moisture at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	4.234
Alumina,	8.577
Oxide of iron,	5.745
Carbonate of lime,	3.880
Magnesia,	1.476
Brown oxide of manganese,	.590
Phosphoric acid,	.513
Sulphuric acid,	.059
Potash,	.354
Soda,	.059
Sand and insoluble silicates,	74.780
	100.267

The sub-soil differs but little in composition from soil on the surface of the field.

No. 624—Soil. *Labeled "Virgin soil from woodland pasture, W. Sm'th's farm, Bryantsville, Garrard county, Kentucky. Lower Silurian formation."*

The dried soil is of a light yellowish-umber color. Washed with water it left 82.75 per cent. of sand, &c., of which all but 5.40 per cent.

was fine enough to go through the finest bolting-cloth. This coarser portion consisted of small rounded soft ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly five grains of light chesnut-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.070
Alumina, oxides of iron and manganese, and phosphates,	.853
Carbonate of lime,	2.488
Magnesia,	.111
Sulphuric acid,	.056
Potash,	.094
Soda,	.042
Silex,	.218
	4.932

The air-dried soil lost 3.35 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	4.640
Alumina,	3.140
Oxide of iron,	2.875
Carbonate of lime,	.420
Magnesia,	.692
Brown oxide of manganese,	.270
Phosphoric acid,	.379
Sulphuric acid,	.102
Potash,	.121
Soda,	.045
Sand and insoluble silicates,	88.220
	100.904

No. 625—SOIL. *Labeled "Same soil (as the preceding,) from an adjoining field, which has been thirty to forty years in cultivation, Mr. Smith's farm, Bryantsville, Garrard county, Kentucky. Lower Silurian formation."*

Color of the dried soil much like that of the preceding, but a very slight shade darker than that. Washed with water this soil left 77.7 per cent. of sand, &c., of which all but 5.30 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted,

principally, of small rounded ferruginous particles, with very few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up to it *more than three grains of chesnut-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.917
Alumina, oxides of iron and manganese, and phosphates,	.407
Carbonate of lime,	1.620
Magnesia,	.117
Sulphuric acid,	.041
Potash,	.079
Soda,	.031
Silica,	.131
	3.343

The air-dried soil lost 3.365 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.987
Alumina,	3.040
Oxide of iron,	3.844
Carbonate of lime,	.385
Magnesia,	.207
Brown oxide of manganese,	.110
Phosphoric acid,	.335
Sulphuric acid,	.067
Potash,	.106
Soda,	.057
Sand and insoluble silicates,	87.170
	100.308

No. 626—SUB-SOIL. *Labeled "Sub-soil from the same field, thirty to forty years in cultivation, Mr. Smith's farm, Bryantsville, Garrard county, Kentucky. Lower Silurian formation."*

Dried sub-soil of a light greyish-buff color. Washed with water it left 70.77 per cent. of sand, &c., of which all but 3.80 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles, with very few of quartzose.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *less than a grain and a half of greyish-brown extract*, dried at 212° F., which had the following *composition:*

	Grains.
Organic and volatile matters,	0.483
Alumina, oxides of iron and manganese, and phosphates,	.320
Carbonate of lime,	.273
Magnesia,	.043
Sulphuric acid,	.034
Potash,	.035
Soda,	.071
Silica,	.150
	1.409

The air-dried sub-soil lost 2.915 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.945
Alumina,	3.815
Oxide of iron,	3.290
Carbonate of lime,	.170
Magnesia,	.412
Brown oxide of manganese,	.210
Phosphoric acid,	.251
Sulphuric acid,	.042
Potash,	.120
Soda,	.018
Sand and insoluble silicates,	89.095
	100.368

Although the soil of the *"old field"* is slightly darker colored than the *virgin soil*, and contains a little more of organic and volatile matters than that, which is rather an unusual circumstance, we yet observe that it has undergone a sensible deterioration, during the thirty to forty years of cultivation to which it has been subjected, having lost not only some of its potash and phosphoric and sulphuric acids, but also of its lime, magnesia, and oxide of manganese. Except in the proportion of potash the sub-soil seems to be less rich than the surface-soil above it.

GRANT COUNTY.

No. 627—Soil. *Labeled "Virgin soil, principally derived from argillaceous rocks. Lower Silurian formation, Hayden Kendall's farm, on the Covington turnpike, seven miles from Williamstown; Grant county, Kentucky. Primitive forest growth, poplar and white oak."*

Color of the dried soil brownish-grey. Washed with water it left 81.03 per cent. of sand, &c., of which all but 1.97 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted of fine rounded ferruginous particles, with a very few quartzose.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than three grains of light brownish-grey extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.730
Alumina, and oxides of iron and phosphates,	.180
Carbonate of lime,	1.199
Magnesia,	.109
Brown oxide of manganese,	.197
Sulphuric acid,	.039
Potash,	.137
Soda,	.027
Silica,	.384
Loss,	.168
	3.170

The air-dried soil lost 3.15 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.212
Alumina,	2.530
Oxide of iron,	2.595
Carbonate of lime,	.247
Magnesia,	.472
Brown oxide of manganese,	.222
Phosphoric acid,	.283
Sulphuric acid,	.093
Potash,	.186
Soda,	.083
Sand and insoluble silicates,	87.845
Loss,	.232
	100.000

No. 628—Soil. *Labeled "Soil from an old field, forty to fifty years in cultivation, Hayden Kendall's farm, seven miles from Williamstown, on the Covington turnpike. Lower Silurian formation. Grant county, Kentucky."*

Color of the dried soil slightly lighter than that of the preceding. Washed with water it left 76.53 per cent. of sand, &c., of which all but 4.93 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted principally of soft rounded ferruginous particles, with a few quartz grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than two and a half grains of grey-brown extract, dried at* 212° *F.*, which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.413
Alumina, oxide of iron, and phosphates,	.222
Carbonate of lime,	1.082
Magnesia,	.146
Brown oxide of manganese,	.198
Sulphuric acid,	.043
Potash,	.122
Soda,	.047
Silica,	.281
Loss,	.036
	2.590

The air-dried soil lost 3.135 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.572
Alumina,	3.520
Oxide of iron,	3.115
Carbonate of lime,	.247
Magnesia,	.433
Brown oxide of manganese,	.222
Phosphoric acid,	.135
Sulphuric acid,	.080
Potash,	.183
Soda,	.071
Sand and insoluble silicates,	87.595
	100.173

No. 629—SUB-SOIL. *Labeled "Sub-soil, from Hayden Kendall's farm, &c., &c., Grant county, Kentucky."* (*See the two preceding soils.*)

The dried sub-soil is of a slightly lighter color than the preceding, and somewhat more of a reddish tint. It is in the form of cloddy lumps. Washed with water it left 76.5 per cent. of sand, &c., of which all but 2.93 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted of small rounded particles of soft ferruginous mineral.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *nearly a grain and a half of light brownish-grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.237
Alumina, oxides of iron and manganese, and phosphates,	.130
Carbonate of lime,	.430
Magnesia,	.333
Sulphuric acid,	.034
Potash,	.071
Soda,	.002
Silica,	.191
	1.428

The air-dried soil lost 2.415 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.111
Alumina,	3.745
Oxide of iron,	3.425
Carbonate of lime,	.147
Magnesia,	.379
Brown oxide of manganese,	.212
Phosphoric acid,	.244
Sulphuric acid,	.045
Potash,	.222
Soda,	.052
Sand and insoluble silicates,	88.650
	100.232

The usual fact of the diminution, by cultivation of the soil, of those ingredients which are essential to the vegetable composition, is to be

observed in these soils also. The sub-soil appears to be somewhat richer in phosphoric acid and potash than the surface-soil.

No. 630—SOIL. *Labeled "Soil from the milk-sick region of Grant county, Kentucky, Moses Theobald's farm, five miles north of Williamstown."*

The color of the air-dried soil is light greyish-buff. Washed with water it left 78.56 per cent. of sand, &c., of which all but 4.33 per cent. was fine enough to pass through the bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *more than two and a half grains of dark-brown extract, dried at* 212° *F.*, which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.380
Alumina, oxides of iron and manganese, and phosphates,	.463
Carbonate of lime,	.489
Magnesia,	.030
Sulphuric acid,	.058
Potash,	.089
Soda,	.053
Silica,	.131
	2.743

The air-dried soil lost 3.225 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	6.162
Alumina,	2.815
Oxide of iron,	2.734
Carbonate of lime,	.196
Magnesia,	.399
Brown oxide of manganese,	.170
Phosphoric acid,	.203
Sulphuric acid,	.072
Potash,	.133
Soda,	.113
Sand and insoluble silicates,	87.045
	100.042

There is nothing peculiar in the composition of this soil, which would tend to explain the cause of this sickness, which sometimes prevails in the region whence it was taken.

No. 631—SANDSTONE. *Labeled "Mud-stone from the milk-sick region of Grant county, Kentucky; at Moses Theobald's, five miles north of Williamstown."*

A dirty-buff colored, friable, impure, shaley sandstone; adheres to the tongue; some thin coatings of dark colored mineral, probably oxide of manganese, on the surfaces of some of the irregular layers.

Dried at 212° F., it lost 1.95 per cent. of *moisture*.

Composition, dried at 212° F.—

Alumina, oxides of iron and manganese,	6.202
Carbonate of lime,	.563
Magnesia,	.766
Phosphoric acid,	.378
Sulphuric acid,	.117
Potash,	.363
Soda,	.200
Sand and insoluble silicates,	89.620
Water expelled at a red heat,	1.950
	100.159

The sand and insoluble silicates contained more than 77. per cent. of silica. Nothing in the composition of this mudstone appears to throw any light on the origin of milk-sickness.

GREENUP COUNTY.

No. 632—CARBONATE OF IRON. *Labeled "Iron ore, (No. 1, the upper part,) from Messrs. Burr, McGrew & Co., Raccoon Furnace, Greenup county, Kentucky. Taken from the hills, just under the hearth-stone rock, placed in Dr. Owens section 215 feet above the level of Raccoon creek. The ore-bed is almost 18 inches thick, and is about three feet below the rock, with dark shale intervening."*

A carbonate of iron ore, varying from yellowish-brown and granular to darker and more compact and cellular; powder, of an average portion, of a brownish-yellow color.

Composition, dried at 212° F.—

Carbonate of iron, - -	42.26	= 52.95 per cent. of *Iron*.
Oxide of iron, - -	46.45	
Carbonate of lime, - -	.48	
Carbonate of magnesia, -	.38	
Carbonate of manganese, -	1.48	
Alumina, - - - - -	.38	
Phosphoric acid, - -	.76	
Sulphur - - -	.09	
Alkalies, (not estimated.)		
Silex and insoluble silicates, -	2.98	
Combined water, - -	4.00	
Loss, - - - - - -	.74	
	100.00	

A very good ore, almost too rich in oxide of iron to be successfully smelted in the high furnace, except in mixture with poorer silicious ores and limestone. (See next numbers.) The proportion of phosphoric acid is considerable, but probably not so great as to injure the quality of the iron produced from it.

No. 633—Carbonate of Iron. *Labeled "Iron ore, lower part of same bed as the preceding. Burr, McGrew & Co., Raccoon Furnace, Greenup county, Kentucky."*

General color dark purplish-brown; under the lens it appears to be made up of minute reddish-brown particles, with some intervening whitish material; adheres slightly to the tongue; a few glimmering specks of mica are seen through it.

Dried at 212° F. it lost 1.10 per cent. of moisture.

Composition, dried at 212° F.—

Carbonate of iron, - - -	51.24	= 31.62 per cent. of *Iron*.
Oxide of iron, - - -	9.42	
Carbonate of lime, - - -	.68	
Carbonate of magnesia, - -	2.76	
Carbonate of manganese, -	1.31	
Alumina, - - - -	1.09	
Phosphoric acid, - - -	.64	
Sulphur, - - - - -	.09	
Potash, - - - - -	.15	
Soda, - - - - -	.23	
Silex and insoluble silicates, -	32.48	
	100.09	

A very good ore, which requires only limestone to smelt it. It could be advantageously mixed with the preceding ore; but for this purpose the mineral next to be described may perhaps be better, as it contains a larger proportion of silicious matter and a smaller amount of oxide of iron with some combustible matter.

No. 634—LIMONITE (IMPURE.) *Labeled "Iron ore? (No. 3,) from Messrs. Burr, McGrew & Co., Raccoon Furnace, Greenup county, Kentucky. (Black band ore?) A bed about 18 inches thick, with 6 inches of coal under it, where it out-crops, about 200 feet above the level of Coal branch, about 3 miles from the Ohio river."*

Dried at 212° F., it lost 3.40 per cent. of moisture.

Composition, dried at 212° F.—

Oxide of iron,	20.87	= 14.61 per cent. *Iron*.
Alumina,	.69	
Carbonate of lime, a trace.		
Carbonate of magnesia,	3.24	
Brown oxide of manganese,	.18	
Phosphoric acid,	.31	
Sulphur,	.25	
Potash,	.38	
Soda,	.10	
Bituminous matter,	9.83	
Silex and insoluble silicates,	60.28	
Combined water,	3.15	
Loss,	.72	
	100.00	

HANCOCK COUNTY.

No. 635—LIMONITE. *Labeled "Iron ore from Mr. Pate's farm, one mile north of the Hardensburg road, Hancock county, Kentucky. Coal Measures."*

A cellular, dark-brown limonite; slightly adhering to the tongue; with some of the cavities filled yellow and red ochreous ore; powder of a brownish-yellow color.

Dried at 212° it lost 1.30 per cent. of *moisture*.

Composition, dried at 212° F.—

Oxide of iron,	34.60	— 24.23 per cent. of *Iron*.
Alumina,	1.38	
Lime, a trace.		
Magnesia,	.50	
Sulphur,	.06	
Potash,	.67	
Soda,	.17	
Combined water,	6.50	
Silex and insoluble silicates,	55.58	
Loss,	.54	
	100.00	

A poor silicious ore.

No. 636—Soil. *Labeled "Uncultivated upland soil from Mr. M. E. Pate's farm. Lower Coal Measures, based on ferruginous sandstone; primitive forest growth very large white oak, poplar, ash, some little sugar-tree, cherry, mulberry, chesnut, large dogwood, and black-walnut; undergrowth, pawpaw and spice-bush. Hancock county, Kentucky."*

Dried soil mouse-colored. Washed with water it left 81.3 per cent. of sand, &c., of which all but 19.3 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted mainly of small rounded ferruginous particles, with very few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly five grains of grey-buff extract, dried at* 212° *F.*, which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.530
Alumina, oxide of iron, and phosphates,	.308
Carbonate of lime,	1.679
Magnesia,	.420
Brown oxide of manganese,	.428
Sulphuric acid,	.034
Potash,	.152
Soda,	.047
Silica,	.149
Loss,	.133
	4.890

The air-dried soil lost 3.325 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	6.022
Alumina,	2.295
Oxide of iron,	2.390
Carbonate of lime,	.310
Magnesia,	.334
Brown oxide of manganese,	.145
Phosphoric acid,	.196
Sulphuric acid,	.096
Potash,	.250
Soda,	.054
Sand and insoluble silicates,	87.910
	100.002

No. 637—SOIL. *Labeled "Same soil as the preceding, from Mr. M. E. Pate's farm, from a field twenty-six years in cultivation, Hancock county, Kentucky."*

Dried soil of a dark buff-grey color. Washed with water it left 76.23 per cent. of sand, &c., of which all but 11.2 per cent. was fine enough to pass through the finest bolting-cloth. This portion is principally small rounded ferruginous particles, with a few of clear quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly two grains of light grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.490
Alumina, oxide of iron, and phosphates,	.128
Carbonate of lime.	.848
Magnesia,	.106
Brown oxide of manganese,	.089
Sulphuric acid,	.016
Potash,	.065
Soda,	.013
Silex,	.039
Loss,	.026
	1.820

The air-dried soil lost 3.415 per cent. of *moisture,* at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.883
Alumina,	2.120
Oxide of iron,	2.430
Carbonate of lime,	.240
Magnesia,	.278
Brown oxide of manganese,	.260
Phosphoric acid,	.063
Sulphuric acid,	.067
Potash,	.174
Soda,	.066
Sand and insoluble silicates,	91.070
Loss,	.349
	100.000

No. 638—SUB-SOIL. *Labeled "Sub-soil from Mr. M. E. Pate's, uncultivated land, &c., Hancock county, Kentucky."*

Color of the dried sub-soil dirty reddish-orange. Washed with water it left 78. per cent. of sand, &c., of which all but 0.3 per cent. passed through the finest bolting-cloth. This consisted of rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, left *more than a grain of nearly white extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.270
Alumina, oxides of iron and manganese, and phosphates,	.068
Carbonate of lime,	.328
Magnesia,	.166
Sulphuric acid,	.030
Potash,	.071
Soda,	.056
Silica,	.139
	1.128

The air-dried soil lost 3.175 per cent. of *moisture,* at 400° F., dried at which temperature it has the following *composition*:

Organic and volatile matters,	3.020
Alumina,	4.190
Oxide of iron,	4.865
Carbonate of lime,	.130
Magnesia,	.605

Brown oxide of manganese,	.070
Phosphoric acid,	.107
Sulphuric acid,	.101
Potash,	.219
Soda,	.055
Sand and insoluble silicates,	86.645
	100.000

The original virgin soil contains a large proportion of organic and volatile matters, and thus gives up a considerable amount of *extract* to the water charged with carbonic acid; this enables it to sustain very large crops, or causes it to lose much under the washing action of rains, &c., and, just in the same proportion, more speedily exhausts the soil, if it be not sustained by the application of manures. This, probably, is the reason why the soil which has been only twenty-six years in cultivation has lost more of its valuable ingredients than many other soils which have been under the plow for twice that period.

No. 639—Clay. *Labeled "Fire-clay, on Mr. Miller's land; Lewisport; used for making yellow queensware. Coal Measures. Hancock county, Kentucky."*

General color of the clay light-grey, mottled, with yellowish and brownish portions, and containing a few small scales of mica; powder of a light buff color; after calcination of a light salmon color.

Dried at 212° F., it lost 2.94 per cent. of *moisture.*

Composition, dried at 212° F.—

Alumina, dissolved out by hydrochloric acid,	3.280
Alumina, combined with silex in insoluble silicates,	20.760
Oxides of iron and manganese,	2.400
Silica, (of which there is 38.79 sand,)	64.880
Carbonate of lime,	.486
Magnesia,	.500
Potash,	.289
Soda,	.389
Water expelled at a red heat,	6.666
Loss,	.350
	100.000

If it were not for the 2.400 per cent. of oxides of iron and manganese contained in this clay it would burn perfectly white, and would then serve for the basis of an extensive manufacture of queensware.

A manufacture, which in view of the very large consumption of this ware in this country, and the immense capital which is annually transferred to England to purchase it, it would be exceeding desirable to establish here.

If a sufficiently pure clay for this purpose cannot be found in our Coal Measures, it is probable that digestion of this and similar clays in *diluted* hydrochloric acid; which, if the manufacture of soda from common salt is also carried on in the neighborhood, would cost scarcely any thing, might remove most of the objectionable oxides, as well as render the clay less fusible under the action of a very high temperature, by dissolving out also its lime and magnesia.

No. 640—CLAY. *Labeled "Clay used as potter's clay; under the first coal under the Lewisport coal; from George Smith's farm, Hancock county, Kentucky."*

Light bluish and yellowish-grey plastic clay.

Dried at 212° F., the air-dried clay lost 6.40 per cent. of *moisture*.

Composition, dried at 212° F.—

Alumina, and oxides of iron and manganese, dissolved out by hydrochloric acid,	1.690
Carbonate of lime,	.140
Magnesia,	.466
Potash,	.336
Water expelled at the red heat,	6.400
Silex and insoluble silicates,	91.020
	100.052

The portion insoluble in hydrochloric acid, denominated silex and insoluble silicates, contained the following ingredients, viz:

Silica,	68.150
Alumina,	20.120
Lime, a trace.	
Magnesia,	.266
Loss, &c.	2.484
	91.020

(See remarks on the preceding clay.)

HARDIN COUNTY.

No. 641—SOIL. *Labeled "Virgin soil, from the base of the Salt river hills; near the base of the slope of the encrinital chert limestone, and limestone of the lower sub-carboniferous formation in Hardin county, Kentucky."*

Dried soil of buff-grey color. Washed with water it left 68.4 per cent. of sand, &c., of which all but 4.25 per cent. was fine enough to go through the finest bolting-cloth. This coarser part consisted mainly of rounded ferruginous particles, with some hyaline and red quartz grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than two grains of greyish-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.730
Alumina, oxide of iron, and phosphates,	.068
Carbonate of lime,	.498
Magnesia,	.087
Brown oxide of manganese,	.069
Sulphuric acid,	.100
Potash,	.088
Soda,	.058
Silica,	.380
	2.078

The air-dried soil lost 3.76 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.069
Alumina,	1.936
Oxide of iron,	2.860
Carbonate of lime,	.270
Magnesia,	.388
Brown oxide of manganese,	.236
Phosphoric acid,	.396
Sulphuric acid,	.054
Potash,	.208
Soda,	.006
Sand and insoluble silicates,	88.096
Loss,	.481
	100.000

With the exception of the very small proportion of sulphuric acid which this analysis exhibits, it indicates quite a good quality of soil. The deficiency stated can easily be supplied by the addition of Plaster of Paris to the land.

No. 642—Soil. *Labeled "Virgin soil, from near the top of the Salt river hills. Lower Sub-carboniferous formation. Primitive forest growth black and white oak, hickory, ash, dogwood, &c. (See Dr. Owen's Report.) Hardin county, Kentucky."*

Color of the dried soil, dark drab-grey. Washed with water it left 82.8 per cent. of sand, &c., of which all but 0.68 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded particles of clear, milky and red quartz, and of a hard ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly a grain and a half of brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.600
Alumina, oxides of iron and manganese, and phosphates,	.297
Carbonate of lime,	.130
Magnesia,	.053
Sulphuric acid,	.045
Potash,	.121
Soda,	.020
Silica,	.200
	1.466

The air-dried soil lost 1.60 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.443
Alumina,	1.715
Oxide of iron,	1.440
Carbonate of lime,	.022
Magnesia,	.209
Brown oxide of manganese,	.095
Phosphoric acid,	.079
Sulphuric acid,	.016

Potash,	.167
Soda,	.032
Sand and insoluble silicates,	93.020
Loss,	.762
	100.000

The small proportions of lime, phosphoric acid, and sulphuric acid, as well as of organic matters and alumina and oxide of iron, to the sand and silicates, and the small amount of soluble matter extracted from it by water containing carbonic acid, demonstrate this to be comparatively a sterile soil. The potash exists in it in average proportion, however, and doubtless, by the proper application of lime, (or calcareous marl,) Plaster of Paris, and bone-dust or super-phosphate of lime, guano, or other phosphatic manures, this soil might be made to support the vine or the peach tree; or, with proper management, yield pretty good crops of corn, &c.

No. 643—SOIL. *Labled "Virgin soil from oak woods or upland, at Mr. Howell's farm, eleven miles from Elizabethtown, Hardinsburg road, Hardin county, Kentucky. Sub-carboniferous formation."*

Dried soil of a grey-buff color. Washed with water this soil left 76.57 per cent. of sand, &c., of which all but 1.47 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted mainly of rounded particles of clear, yellowish and reddish quartz, with a few of a ferruginous mineral.

One thousand grains of the air-dried soil, digested in water charged with carbonic acid, gave up *more than two and a half grains of dark brown extract,* dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.827
Alumina, oxides of iron and manganese, and phosphates,	.687
Carbonate of lime,	.830
Magnesia,	.063
Sulphuric acid,	.011
Potash,	.106
Soda,	.041
Silex,	.177
	2.742

The air-dried soil lost 1.965 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	3.417
Alumina,	2.245
Oxide of iron,	2.075
Carbonate of lime,	.197
Magnesia,	.203
Brown oxide of manganese,	.095
Phosphoric acid,	.177
Sulphuric acid,	.067
Potash,	.104
Soda,	.013
Sand and insoluble silicates,	91.445
	100.100

No. 644—Soil. *Labeled "Same soil, faom Mr. Howard's field, thirty-nine years in cultivation, Hardin county, Kentucky. Sub-carboniferous formation, &c., &c."*

Dried soil of a grey-buff color; lighter than the preceding. Washed with water it left 79-07 per cent. of sand, &c., of which all but 1.60 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded particles of clear, yellowish, and reddish quartz, with a few of sandstone, &c.

One thousand grains of the air-dried soil, digested in water containing carbonic acid, gave up nearly two grains of dark-brown extract, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.800
Alumina, oxides of iron and manganese, and phosphates,	.647
Carbonate of lime,	.163
Magnesia,	.072
Sulphuric acid,	.033
Potash,	.083
Soda,	.037
Silica,	.157
	1.992

This air-dried sub-soil lost 1.50 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.309
Alumina,	1.745
Oxide of iron,	1.420
Carbonate of lime,	.097
Magnesia,	.191
Brown oxide of manganese,	.040
Phosphoric acid,	.078
Sulphuric acid,	.021
Potash,	.075
Soda,	.030
Sand and insoluble silicates,	93.495
Loss,	.499
	100.000

No. 645—SUB-SOIL. *Labeled "Sub-soil from Mr. Howell's field, thirty-nine years in cultivation, eleven miles from Elizabethtown, Hardinsburg road, Hardin county, Ky. Sub-carboniferous formation, &c."*

Dried sub-soil is of a greyish-buff color; of rather purer and deeper buff than the two preceding soils. Washed with water it left 73.20 per cent. of sand, &c., of which all but 1.57 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded particles of clear white and reddish qurartz, with some soft ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *more than two grains of dark brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.750
Alumina, oxides of iron and manganese, and phosphates,	.230
Carbonate of lime,	.713
Magnesia,	.061
Sulphuric acid,	.033
Potash,	.083
Soda,	.025
Silica,	.197
	2.093

The air-dried sub-soil lost 1.965 per cent. of *moisture*, at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	2.407
Alumina,	2.670
Oxide of iron,	2.415
Carbonate of lime,	.147
Magnesia,	.324
Brown oxide of manganese,	.070
Phosphoric acid,	.096
Sulphuric acid,	.028
Potash,	.092
Soda,	.024
Sand and insoluble silicates,	91.395
Loss,	.332
	100.000

The soil of the old field, thirty-nine years in cultivation, exhibits considerable exhaustion of its essential elements. The sub-soil does not appear to contain as much of them as the original surface soil. The use of lime or calcareous marl, of Plaster of Paris, and of some phosphatic manure, with ashes, or any other substance containing potash, would much increase the fertility of the cultivated field.

HARRISON COUNTY.

No. 646—Soil. *Labeled "Virgin soil, James Miller's farm, three miles south of Cynthiana, woods pasture; forest growth large black walnut, sugar-tree, white oak, blue ash, and poplar. Lower Silurian formation. Harrison county, Ky."*

Dried soil of a dark-buff color. Washed with water it left 89.40 per cent. of sand, &c., of which all but 7.40 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion mainly consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *more than four grains of brown-grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.217
Alumina, oxides of iron and manganese, and phosphates,	.563
Carbonate of lime,	2.580
Magnesia,	.072
Sulphuric acid,	.062
Potash,	.185

Soda,	.070
Silica,	.098
	4.847

The air-dried soil lost 3.325 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition*:

Organic and volatile matters,	7.721
Alumina,	3.540
Oxide of iron,	3.865
Carbonate of lime,	.466
Magnesia,	.483
Brown oxide of manganese,	.420
Phosphoric acid,	.394
Sulphuric acid,	.114
Potash,	.170
Soda,	.077
Sand and insoluble silicates,	82.895
	100.145

No. 647—SOIL. *Labeled "Soil from an old field, sixty to seventy years in cultivation, James Miller's farm, three miles south of Cynthiana, Harrison county, Kentucky. Lower Silurian formation."*

Dried soil of a dirty-buff color; somewhat lighter than that of the preceding soil. Washed with water it left 78.70 per cent. of sand, &c., of which all but 4.43 per cent. was fine enough to pass through the finest bolting-cloth. This latter portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *more than four grains of light-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.917
Alumina, oxides of iron and manganese, and phosphates,	.530
Carbonate of lime,	2.080
Magnesia,	.100
Sulphuric acid,	.067
Potash,	.168
Soda,	.084
Silica,	.131
	4.077

The air-dried soil lost 2.75 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	6.051
Alumina,	3.655
Oxide of iron,	3.835
Carbonate of lime,	.296
Magnesia,	.463
Brown oxide of manganese,	.480
Phosphoric acid,	.385
Sulphuric acid,	.107
Potash,	.159
Soda,	.105
Sand and insoluble silicates,	84.630
	100.166

No. 648—SUB-SOIL. *Labeled "Sub-soil from the old field, sixty to seventy years in cultivation, James Miller's farm, three miles south of Cynthiaua, Harrison county, Kentucky. Lower Silurian formation."*

Color of the dried sub-soil rather purer buff than the preceding. Washed with water it left 74.70 per cent. of sand, &c., of which all but 6.03 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried sub-soil, digested for twenty days in water containing carbonic acid, gave up *more than three grains of brownish extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.550
Alumina, oxides of iron and manganese, and phosphates,	.230
Carbonate of lime,	1.831
Magnesia,	.083
Sulphuric acid,	.062
Potash,	.131
Soda,	.075
Silica,	.131
	3.093

The air-dried sub-soil lost 2.825 per cent. of *moisture,* at 400° F., dried at which temperature it had the following *composition:*

Organic and volatile matters,	5.119
Alumina,	3.565
Oxide of iron,	3.660
Carbonate of lime,	.313
Magnesia,	.491
Brown oxide of manganese,	.345
Phosphoric acid,	.316
Sulphuric acid,	.101
Potash,	.151
Soda,	.090
Sand and insoluble silicates,	85.710
Loss,	.139
	100.000

The analyses show the usual influence of exhaustive cultivation upon the soil. The sub-soil of the old field is not quite as rich as the original surface soil, but yet richer than the surface soil of the old field itself.

HENRY COUNTY.

No. 649—SOIL. *Labeled "Virgin soil, from woodland pasture, John Hornback's land, two miles south of New-Castle; primitive forest growth, white oak, sugar tree, blue ash, shell-bark hickory, and pin oak. Lower Silurian formation. Henry county, Kentucky."*

The dried soil is of a dark greyish-buff color. Washed with water it left 80.96 per cent. of sand, &c., of which all but 2.03 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous concretions, with very few of chert.

One thousand grains of the air-dried soil, digested in water charged with carbonic acid, gave up *more than four and a half grains of chesnut-brown extract*, dried at 400° F.; which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.383
Alumina, oxides of iron and manganese, and phosphates,	.930
Carbonate of lime,	1.677
Magnesia,	.128
Sulphuric acid,	.045
Potash,	.185
Soda,	.155
Silica,	.114
	4.617

The air-dried sub-soil lost 4.075 per cent. of moisture at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	5.180
Alumina,	2.515
Oxide of iron,	3.940
Carbonate of lime,	.372
Magnesia,	.503
Brown oxide of manganese,	.170
Phosphoric acid,	.615
Sulphuric acid,	.101
Potash,	.284
Soda,	.132
Sand and insoluble silicates,	85.900
Loss,	.288
	100.000

No. 650—Soil. *Labeled "Same soil (as preceding,) from an old field, fifty years or more in cultivation, now in corn, John Hornback's farm, two miles south of New Castle, Henry county, Kentucky."*

Color of the dried soil dark greyish-buff; a little lighter than that of the virgin soil. Washed with water it left 74.47 per cent. of sand, &c., of which all but 1.93 per cent. was fine enough to pass through the finest bolting-cloth. This portion is principally small rounded ferruginous particles with a few of chert.

One thousand grains of the air-dried soil, digested for a month in the water containing carbonic acid, gave up *nearly two and a half grains of brownish extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.250
Alumina, oxides of iron and manganese, and phosphates,	.487
Carbonate of lime,	1.280
Magnesia,	.096
Sulphuric acid,	.056
Potash,	.058
Soda,	.048
Silex,	.164
	2.439

The air-dried soil lost 3.935 per cent. of *moisture,* at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	5.159
Alumina,	3.915
Oxide of iron,	4.115
Carbonate of lime,	.496
Magnesia,	.558
Brown oxide of manganese,	.220
Phosphoric acid,	.407
Sulphuric acid,	.101
Potash,	.298
Soda,	.133
Sand and insoluble silicates,	83.760
Loss,	.838
	100.000

No. 651—SUB-SOIL. *Labeled "Sub-soil from the same old field, fifty years or more in cultivation, John Hornback's land, Henry county, Kentucky, &c."*

Color of the dried sub-soil like that of the preceding, but a little more buff. Washed out about 77.47 per cent. of sand, &c., of which only 2.30 per cent. was too coarse to pass through the finest bolting-cloth. This portion is principally composed of small rounded ferruginous particles, with a few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, *gave up nearly three and a half grains of nearly black extract, dried at* 212° *F.*, which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.440
Alumina, oxides of iron and manganese, and phosphates,	.301
Carbonate of lime,	1.313
Magnesia,	.033
Sulphuric acid,	.045
Potash,	.032
Soda,	.154
Silica,	.064
	3.382

The air-dried sub-soil lost 4.11 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.918
Alumina,	4.125
Oxide of iron,	4.545
Carbonate of lime,	.396
Magnesia,	.512
Brown oxide of manganese,	.160
Phosphoric acid,	.448
Sulphuric acid,	.085
Potash,	.227
Soda,	.067
Sand and insoluble silicates,	84.943
	100.426

These soils present almost the only anomaly, in the whole of the soils analyzed, of the existence of larger proportions of lime, magnesia, oxide of manganese, potash, and soda, and a smaller proportion of sand and insoluble silicates, in the soil of the old field than in the virgin soil from the same neighborhood. The organic and volatile matters are in nearly similar quantities in the two soils, but the virgin soil gives up a much larger proportion of soluble extract to the water charged with carbonic acid; and the amount of phosphoric acid, in this latter, is also much the larger. If no error has been committed in putting up and labeling the soils, or no accidental substitution has occurred since, this anomaly can only be explained on the supposition that the soil of the old field was originally much stronger than that of the neighboring one from whence the "virgin soil" was taken—a case which seems to be rare. The sub-soil does not appear to be better than the soil of the old field.

HOPKINS COUNTY.

No. 652—*Labeled "Efflorescence, from a corn field, Steuben's Lick, Hopkins county, Kentucky. Coal Measures."*

A moist powder, of a grey-buff color, having a saline taste, and containing sand, &c.

Five hundred grains of the moist powder gave up, to distilled water, of nearly 88. grains of *saline matter*, dried at 212° F.—equal to more than seventeen and a half per cent.—which had the following *composition:*

	In 500 *grains.*		*Per cent. of the moist earth.*
Sulphate of soda, - - - -	56.82	=	11.364
Sulphate of magnesia, - -	4.92	=	.984
Sulphate of lime, - -	2.19	=	.438
Sulphate of potash, - -	1.38	=	2.76
Chloride of sodium, - -	17.25	=	3.450
Chloride of calcium, - -	.72	=	.144
Silica, - - - - - -	.13	=	.026
Organic matter, water, and loss,	4.51	=	.902
	87.92		17.584

It contains also traces of nitrates.

Probably some mineral spring sends its waters into the soil or sub-soil, and the efflorescence is caused by the evaporation of the water on the surface of the soil, leaving the salts there; or the saline matters exist in the sub-strata, and are brought up, (by known physical laws,) by the water which moistens the soil.

No. 653—LIMONITE. *Labeled "Iron ore at Jerry Bruce's, Clear creek, south-west of Providence, Hopkins county, Kentucky."*

A cellular limonite; containing some sand grains, and specks of mica, and exhibiting the impression of a fossil shell. The cells are lined with ochreous ore; the general color liver-brown; not adhering to the tongue; the powder of this ore is of a Spanish brown color, changing to black on calcination, although it does not contain any carbonate of the protoxide of iron. The air-dried ore lost 0.90 per cent. of *moisture*, at 212° F.

Specific gravity - - - - - - - - 2.785

Composition, dried at 212° F.—

Oxide of iron, - - -	54.080	= 37.87 per cent. of *Iron.*
Alumina, - - - -	1.380	
Lime, a trace.		
Magnesia, - - - -	.244	
Brown oxide of manganese, -	.720	
Phosphoric acid, - - -	1.400	
Sulphur - - - -	.210	
Potash, - - - -	.251	
Soda, - - - -	.055	
Silex and insoluble silicates, -	34.480	
Combined water and loss, -	7.180	
	100.000	

A good silicious iron ore, with the only draw-back, that it has more phosphoric acid in its composition than is desirable for the manufacture of tough iron. It would require only the addition of limestone to flux it in the high furnace.

No. 654—LIMONITE. *Labeled "Iron ore, at Benj. Parker's, one and a half miles east of Providence, Hopkins county, Kentucky.*

Dull; adhering to the tongue; presenting various shades of dark red. Powder of a dark Spanish brown color. The air-dried ore lost 2.20 per cent. of *moisture*, at 212° F.

Composition, dried at 212° F.—

Oxide of iron,	62.250	= 43.593 per cent. of *Iron*.
Alumina,	5.820	
Carbonate of lime,	2.040	
Magnesia,	6.432	
Brown oxide of manganese,	.860	
Phosphoric acid,	1.170	
Sulphur,	.356	
Potash,	.571	
Soda, a trace.		
Silex and insoluble silicates,	12.180	
Combined water,	8.800	
	100.479	

A richer ore than the preceding; less silicious, and containing much more lime and magnesia. The phosphoric acid is but little less in this than in the preceding.

No. 655—LIMONITE? *Labeled "Iron ore at Jack Segler's, one mile and a half north west of Providence, head of Owen and Plover creeks, Hopkins county, Kentucky."*

A dense, fine grained, dark-colored ore, some whitish mineral infiltrated into some of its small cavities; not adhering to the tongue; powder of a purple-brown color. The air-dried ore lost 0.40 per cent. of *moistare*, at 212° F.

Specific gravity, - - - - - - - - - 4.563

Composition, dried at 212° F.—

Oxide of iron,	91.780	= 64.266 per cent. *Iron*.
Alumina,	1.035	
Lime, a trace.		
Magnesia,	.221	

Brown oxide of manganese, -	.486
Phosphoric acid, - - -	.055
Sulphur, - - - - -	.031
Potash, - - - -	.154
Soda, - - - - - -	.029
Silex and insoluble silicates, -	5.286
Combined water, - - -	1.140
	100.217

Quite a pure, and a very rich ore of iron; too rich, indeed, to be successfully smelted alone in the high furnace, because it does not contain enough silex and alumina to form slag enough, with the limestone used as flux, to protect the reduced iron from the oxidating influence of the blast. It can be very well managed, however, in proper mixture with poorer, more silicious ores—such, for example, as No. 653, or the one next to be described, or even the impure limestone, No. 658, still further on. This ore is remarkable, from the very small proportion of *combined water* which it contains, which makes it doubtful whether it should not be classed with the *specular* iron ores, and not with the *limonites*.

No. 656—CARBONATE OF IRON. *Labeled "Iron ore, seventeen feet below the surface, at Benj. Parker's well, one and a half miles east of Providence, Hopkins county, Kentucky."*

A dull, dark-grey, carbonate of iron; not adhering to the tongue; powder of a grey color. The air-dried ore lost 0.54 per cent. of *moisture*, at 212° F.

Specific graviy, - - - - - - - - - 3.227

Composition, dried at 212° F.—

Carbonate of iron, - -	61.730	— 26.845 per cent. of *Iron*.
Carbonate of lime, - -	4.890	
Carbonate of magnesia, -	1.848	
Carbonate of manganese, -	.887	
Alumina, - - - - -	.480	
Phosphoric acid, - -	.183	
Sulphur - - -	.122	
Potash. - - - - -	.201	
Soda, - - - - -	.068	
Silex and insoluble silicates, -	27.140	
Bituminous matter, - -	2.800	
	100.339	

This may be called a *grey-band ore*. It is rather too poor, perhaps, to be profitably smelted alone, but could be used in mixture with the richer ores, to furnish cinder.

No. 657—CARBONATE OF IRON. *Labeled "Iron ore, twelve feet below the surface at Benj. Parker's, one and a half miles east of Providence, Hopkins county, Kentucky."*

A dull, dark-grey mineral, adhering slightly to the tongue; exterior of a dull yellowish-brown color; powder, grey-buff. The air-dried ore lost 0.8 per cent. of *moisture*, at 212° F.

Specific gravity,		3.146
Composition, dried at 212° F.—		
Carbonate of iron,	45.119	= 33.86 per cent. of *Iron*.
Oxide of iron,	16.457	
Carbonate of lime,	4.780	
Carbonate of magnesia,	5.616	
Carbonate of manganese,	2.093	
Alumina,	.270	
Phosphoric acid,	1.720	
Sulphur,	.212	
Potash,	.262	
Soda,	.097	
Silica,	19.920	
Water, bituminous matter and loss,	3.454	
	100.000	

Contains rather more phosphoric acid than is desirable in an iron ore; otherwise, a good and sufficiently rich ore, which will require but a small addition of limestone for smelting it.

No. 658—LIMESTONE, (IMPURE.) *Labeled "At Benj. Parker's, one mile and a half east of Providence, Hopkins county, Kentucky."*

A grey, fine-grained, ferruginous limestone; containing small scales of mica; rust-brown on the weathered surfaces; powder of a very light-buff color. The air-dried ore lost 0.24 per cent. of moisture, at 212° F.

Specific gravity, - - - - - - - - 2.778

Composition, dried at 212° F.—

Carbonate of lime,	23.790
Carbonate of iron,	11.717
Carbonate of magnesia,	4.413
Carbonate of manganese,	.586
Alumina,	1.590
Phosphoric acid,	.247
Sulphur,	.006
Potash,	.270
Soda,	.091
Silex and insoluble silicates,	55.120
Water, bituminous matter and loss,	2.170
	100.000

JEFFERSON COUNTY.

No. 659—SOIL. *Labeled "Soil, ten miles from Louisville, on the Salt river road, thirty or forty years in cultivation; primitive growth, beach, and some poplar and gum; spouty land. Jefferson county, Ky."*

Color of the dried soil, dark yellowish-grey. A few small rounded ferruginous pebbles were removed from it by the coarse seive. Washed with water it left 76.33 per cent. of sand, &c., of which all but 4.37 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion is composed of rounded grains of hyaline and yellow quartz with some ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly two grains of light-brown extract*, dried at 212° F., which had the following *composition:*

	Grains.
Organic and volatile matters,	0.370
Alumina, oxides of iron and manganese, and phosphates,	.114
Carbonate of lime,	.880
Magnesia,	.052
Sulphuric acid,	.081
Potash,	.044
Soda,	.081
Silica,	.200
	1.822

The air-dried soil lost 3.10 per cent. *of moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.231
Alumina,	3.580
Oxide of iron,	4.421
Carbonate of lime,	.230
Magnesia,	.359
Brown oxide of manganese,	.445
Phosphoric acid,	.262
Sulphuric acid,	.084
Potash,	.167
Soda,	.045
Sand and insoluble silicates,	86.066
Loss,	.110
	100.000

No. 660—SUB-SOIL. *Labeled "Sub-soil, ten miles from Louisville, on the Salt river road, field thirty to forty years in cultivation,* (*see preceding number.*) *Jefferson county, Kentucky.*"

Color of the dried sub-soil a little lighter than that of the soil above it. The coarse seive removed from it some rounded particles of ferruginous mineral, and a few milky quartz grains about the size of mustard seed. Washed with water, this sub-soil left 70.70 per cent. of sand, &c., of which all but 14.47 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of clear grains of quartz, more or less rounded, with some rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up more than five grains of *brown extract*, dried at 212°, which had the following *composition:*

	Grains.
Organic and volatile matters,	2.100
Alumina, oxides of iron and manganese, and phosphates,	.863
Carbonate of lime,	1.713
Magnesia,	.133
Sulphuric acid,	.125
Potash,	.048
Soda,	.012
Silica,	.200
	5.194

The air-dried soil lost 3.175 per cent. of *moisture* at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.983
Alumina,	3.245
Oxide of iron,	4.130
Carbonate of lime,	.195
Magnesia,	.335
Brown oxide of manganese,	.370
Phosphoric acid,	.295
Sulphuric acid,	.085
Potash,	.213
Soda,	.051
Sand and insoluble silicates,	85.895
Loss,	.203
	100.000

This would be good soil if it were drained. The sub-soil is rather richer than the surface-soil.

JESSAMINE COUNTY.

No. 661—Bituminous Shale. *Brought by Mr. Alexander Headley, from his farm, formerly the "Meade farm," about ten miles from Lexington, Jessamine county, Kentucky."*

A soft, friable shale, having a somewhat smooth, or soapy feel; yielding readily to the nail; color brownish-drab, or purplish-grey; burning, when heated, with a smokey flame.

By distillation in an iron retort, gradually raised to dull redness—three receivers and a bell glass for the gas being attached—one thousand grains of this shale gave the following products, viz:

Crude oil,	50.00 grains.
Ammoniacal water,	58.00 grains.
Black residue,	840.00 grains.
Gas, moisture, and loss,	52.00 grains.
	1000.00 grains.

The gas collected from the thousand grains distilled, as above described, measured one hundred and seventy cubic inches.

It is remarkable that so light colored a shale should contiain so much bituminous matter. As it yields but five per cent. of crude oil it is doubtful whether the products of its distillation would pay for the trouble, fuel, &c.

No. 622—SOIL. *Labeled "Soil, (from woodland,) based on the upper beds of the birds'-eye limestone, two to two and a half miles north of the bridge over the Kentucky river, Jessamine county, Kentucky." Lower Silurian formation.*

A considerable quantity of irregular and angular particles and fragments of chert, and some ferruginous mineral, and a small quartz crystal were sifted out of it with the coarse seive. Washed with water it left 83.90 per cent. of sand, &c., of which all but 6.13 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted mainly of ferruginous particles, with a few of chert and clear quartz.

One thousand grains of the air-dried soil, digested in water charged with carbonic acid, gave up *more than four grains of greyish-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.817
Alumina, oxides of iron and manganese, and phosphates,	.630
Carbonate of lime,	2.313
Magnesia,	.123
Sulphuric acid,	.017
Potash,	.078
Soda,	.032
Silica,	.200
	4.210

The air-dried soil lost 2.90 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.737
Alumina,	2.695
Oxide of iron,	2.890
Carbonate of lime,	.345
Magnesia,	.199
Brown oxide of manganese,	.280
Phosphoric acid,	.133
Sulphuric acid,	.067
Potash,	.121
Soda,	.047
Sand and insoluble silicates,	87.995
Loss,	.491
	100.000

No. 663—SOIL. *Labeled "Soil from an adjoining field, immediately overlaying the upper beds of the birds'-eye limestone, two to two and a half miles north of the bridge over the Kentucky river, adjacent to the turnpike, Jessamine county, Kentucky."*

Some irregular fragments of chert, and some rounded particles of this and of a ferruginous mineral, were removed from this soil by the coarse seive. Washed with water it left 83.60 per cent. of fine sand, of which all but 7.70 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded particles of chert and quartz, &c. Color of the dried soil slightly lighter than that of the preceding.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than three grains of brownish extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.930
Alumina, oxides of iron and manganese, and phosphates,	.330
Carbonate of lime,	1.596
Magnesia,	.072
Sulphuric acid,	.022
Potash,	.052
Soda,	.010
Silica,	.200
	3.212

The air-dried soil lost 2.95 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.250
Alumina,	3.695
Oxide of iron,	3.240
Carbonate of lime,	.295
Magnesia,	.366
Brown oxide of manganese,	.285
Phosphoric acid,	.239
Sulphuric acid,	.050
Potash,	.185
Soda,	.044
Sand and insoluble silicates,	87.245
Loss,	.106
	100.000

No. 664—Soil. *Labeled "Virgin soil, from Mr. Paton's woodland pasture, near his mill, on Hickman creek; primitive forest growth, over-cup and white oak, black walnut and hickory. Lower Silurian formation. Jessamine county, Kentucky."*

The dried soil is of a dirty-buff color. Washed with water it left 77.07 per cent. of sand, &c., of which all but 1.18 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly four grains of chestnut-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.783
Alumina, oxides of iron and manganese, and phosphates,	.830
Carbonate of lime,	1.947
Magnesia,	.094
Sulphuric acid,	.062
Potash,	.096
Soda,	.042
Sand and insoluble silicats,	.131
	3.985

The air-dried soil lost 4.20 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.349
Alumina,	5.065
Oxide of iron,	4.990
Carbonate of lime,	.595
Magnesia,	.750
Brown oxide of manganese,	.220
Phosphoric acid,	.666
Sulphuric acid,	.106
Potash,	.344
Soda, not estimated.	
Sand and insoluble silicates,	81.720
Loss,	.195
	100.000

No. 665—SOIL. *Labeled "Same soil, in a cultivated field, for twelve inches to the underlying rock, (with Orthis testudinaria); no sub-soil; near Mr. Paton's mill, on Hickman creek. Lower Silurian formation. Jessamine county, Kentucky."*

Dried soil of a light-umber color. It contained irregular worn fragments of limestone, containing portions of small encrinital stems. Washed with water this soil left 83.3 per cent. of sand, &c., of which all but 3.20 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than eight grains of reddish-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.990
Alumina, oxide of iron, and phosphates,	.953
Carbonate of lime,	5.430
Magnesia,	.305
Sulphuric acid,	.056
Potash,	.125
Soda,	.043
Silica,	.181
	8.083

The air-dried soil lost 6.775 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition :*

Organic and volatile matters,	9.745
Alumina,	9.190
Oxide of iron,	5.840
Carbonate of lime,	3.570
Magnesia,	1.290
Brown oxide of manganese,	.470
Phosphoric acid,	.532
Sulphuric acid,	.119
Potash,	.569
Soda,	.212
Sand and insoluble silicates,	69.070
	100.607

Both of these soils contain large proportions of the mineral elements of vegetable food. The latter one is superior in this respect to No. 664, and contains as much alumina and oxide of iron and carbonate of lime as is found in some of the under-clays. The soils based on the harder and more durable beds of the bird's-eye limestone, are much less rich in all these materials.

No. 666—LIMESTONE. *Labeled "Limestone, containing Orthis testudinaria, &c., found under the soil, near Paton's mill, Hickman creek, Jessamine county, Kentucky. Lower Silurian formation."*

Irregular, water-worn fragments, of a very fossiliferous, bluish-grey limestone; exterior surface much and irregularly corroded.

Composition, dried at 212 F.—

Carbonate of lime,	92.980	— 52.176 of *Lime*.
Carbonate of magnesia,	.839	
Alumina, and oxides of iron and manganese,	2.040	
Phosphoric acid,	.567	
Sulphuric acid,	.133	
Potash,	.166	
Soda,	.055	
Silex and insoluble silicates,	3.146	
Loss,	.074	
	100.000	

A limestone very rich in phosphoric and sulphuric acids and the alkalies, which seems to be easily disintegrated by the action of water, &c., and hence communicates its valuable ingredients to the soil above it.

KENTON COUNTY.

No. 667—SOIL. *Labeled "Virgin soil, from the Armstrong farm, five miles south-west of Covington; beech land, over the shell beds of the blue limestone of the Lower Silurian formation, Kenton county, Kentucky."*

Dried soil of a dark grey-buff color. Washed by water it left 82.90 per cent. of sand, &c., of which all but 1.02 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of clear and colored quartz, with some ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up nearly two and a half grains of

greyish-brown extract, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.770
Alumina, oxide of iron and manganese, and phosphates,	.337
Carbonate of lime.	.880
Magnesia,	.066
Sulphuric acid,	.037
Potash,	.125
Soda,	.038
Silica,	.100
Loss,	.107
	2.460

The air-dried soil lost 3.935 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.429
Alumina,	3.225
Oxide of iron,	2.520
Carbonate of lime,	.197
Magnesia,	.461
Brown oxide of manganese,	.189
Phosphoric acid,	.226
Sulphuric acid,	.076
Potash,	.272
Soda, a trace.	
Sand and insoluble silicates,	87.445
	100.070

No. 668—SOIL. *Labeled "Same soil, from an old field, forty to fifty years in cultivation, Armstrong farm, five miles south-west of Covington, &c. &c., Kenton county, Kentucky."*

The dried soil is of a dark greyish-buff color, slightly lighter than the last. Washed with water it left 77.00 per cent. of sand, &c., of which all but 4.13 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion is composed of rounded particles of clear and colored quartz, and of ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than a grain and a half of brownish-grey extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.270
Alumina, oxides of iron and manganese, and phosphates,	.160
Carbonate of lime,	.780
Magnesia,	.113
Sulphuric acid,	.022
Potash,	.085
Soda,	.027
Silica,	.200
Loss,	.048
	1.705

The air-dried soil lost 3.210 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.621
Alumina,	3.570
Oxide of iron,	3.245
Carbonate of lime,	.147
Magnesia,	.460
Brown oxide of manganese,	.345
Phosphoric acid,	.206
Sulphuric acid,	.074
Potash,	.212
Soda,	.035
Sand and insoluble silicates,	87.495
Loss,	.590
	100.000

No. 669—SUB-SOIL. *Labeled "Sub-soil from the same old field, forty to fifty years in cultivation, Armstrong farm, &c., &c., Kenton county, Kentucky.*

The dried soil is in cloddy lumps, of a lighter color and more buff than the surface-soil. Washed with water it left 68.23 per cent. of sand, &c., of which all but 2.43 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with some rounded clear quartz grains.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, left *more than a grain and a half of brownish-grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.370
Alumina, oxides of iron and manganese, and phosphates,	.223
Carbonate of lime,	.410
Magnesia,	.044
Sulphuric acid,	.017
Potash,	.096
Soda,	.030
Silica,	.277
Loss,	.163
	1.630

The air-dried sub-soil lost 3.165 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.901
Alumina,	3.660
Oxide of iron,	3.220
Carbonate of lime,	.147
Magnesia,	.478
Brown oxide of manganese,	.320
Phosphoric acid,	.150
Sulphuric acid,	.050
Potash,	.205
Soda,	.060
Sand and insoluble silicates,	88.745
Loss,	.064
	100.000

The forty to fifty years cultivation of the old field has caused a sensible diminution of its essential ingredients. The sub-soil is not as rich in those as the surface-soil.

LARUE COUNTY.

No. 670—Soil. *Labeled "Virgin soil, (small black oak and white oak woods,) on the Stylina beds of the sub-carboniferous limestone, Daniel Canady's farm, stone house, two miles north-east of Hodgenville, Larue county, Kentucky."*

Dried soil of a greyish-buff color Washed with water it left 81.9 per cent. of sand, &c., of which all but 4.03 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded particles of hyaline, yellow, and reddish qurartz, with some soft ferruginous mineral.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than one and a half grains of chocolate-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.715
Alumina, oxides of iron and manganese, and phosphates,	.163
Carbonate of lime,	.317
Magnesia,	.108
Sulphuric acid,	.039
Potash,	.074
Soda,	.017
Silica,	.153
	1.586

The air-dried soil lost 2.625 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	6.428
Alumina,	3.175
Oxide of iron,	2.715
Carbonate of lime,	.072
Magnesia,	.290
Brown oxide of manganese,	.230
Phosphoric acid,	.114
Sulphuric acid,	.050
Potash,	.135
Soda,	.025
Sand and insoluble silicates,	88.680
	101.914

No. 671—SOIL. *Labeled "Same soil, from an old field, thirty to forty years in cultivation, Daniel Canady's farm, two miles north east of Hodgenville, Larue county, Kentucky. Stylina beds of sub-carboniferous limestone."*

Dried soil of a greyish-buff color; slightly lighter than the virgin soil. Washed with water it left 77.13 per cent. of sand, &c., of which all but 2.63 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion is composed of hyaline, yellowish, and reddish quartz, with a few ferruginous grains.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly two grains of brown-*

ish extract, dried at 212° *F.*, which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.683
Alumina, oxides of iron and manganese, and phosphates,	.463
Carbonate of lime,	.453
Magnesia,	.061
Sulphuric acid,	.033
Potash,	.083
Soda,	.021
Silica,	.173
	1.970

The air-dried soil lost 2.425 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition*:

Organic and volatile matters,	5.380
Alumina,	3.175
Oxide of iron,	2.815
Carbonate of lime,	.106
Magnesia,	.342
Brown oxide of manganese,	.245
Phosphoric acid,	.113
Sulphuric acid,	.055
Potash,	.123
Soda,	.021
Sand and insoluble silicates,	89.340
	101.715

No. 672—SUB-SOIL. *Labeled "Sub-soil, from same old field, thirty to forty years in cultivation, Daniel Canady's farm, two miles north-east of Hodgenville, Larue county, Kentucky, &c. &c."*

Dried sub-soil of a dirty-buff color; rather lighter than the two preceding. Washed with water it left 79.07 per cent. of sand, &c., of which all but 2.83 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded grains of hyaline, yellowish, and reddish quartz, with a few ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *more than a grain of light-brown extract*, which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.450
Alumina, oxides of iron and manganese, and phosphates,	.043
Carbonate of lime,	.173
Magnesia,	.081
Sulphuric acid,	.031
Potash,	.096
Soda,	.053
Silica,	.207
	1.134

The air-dried soil lost 2.725 per cent. of *moisture* at 400° F.; dried at which temperature it has the following composition:

Organic and volatile matters,	2.981
Alumina,	3.955
Oxide of iron,	3.265
Carbonate of lime,	.015
Magnesia,	.467
Brown oxide of manganese,	.235
Phosphoric acid,	.096
Sulphuric acid,	.050
Potash,	.130
Soda,	.023
Sand and insoluble silicates,	88.625
Loss,	.158
	100.000

The sub-soil is not richer than the original soil. Applications of lime or calcareous marl, gypsum, (Plaster of Paris,) bone dust, or other phosphatic manures, and ashes, would greatly improve this soil.

MARION COUNTY.

No. 673—SOIL. *Labeled "Virgin soil, from woods on Daniel Everhart's farm, three miles west of Lebanon, Marion county, Kentucky. Devonian?"*

Color of the dried soil, dark-greyish buff. Washed with water it left 83.63 per cent. of sand, &c., of which all but 4.17 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with a few of clear quartz.

One thousand grains of the air-dried soil, digested for a month in

water charged with carbonic acid, gave up *more than three grains of buff-brown extract*, dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	1.460
Alumina, oxides of iron and manganese, and phosphates,	.473
Carbonate of lime,	1.063
Magnesia,	.133
Sulphuric acid,	.036
Potash,	.087
Soda,	.059
Silica,	.098
	3.409

The air-dried soil lost 3.375 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	4.786
Alumina,	6.495
Oxide of iron,	3.565
Carbonate of lime,	.222
Magnesia,	.339
Brown oxide of manganese,	.271
Phosphoric acid,	.262
Sulphuric acid,	.042
Potash,	.157
Soda,	.011
Sand and insoluble silicates,	85.040
	101·190

No. 674—SOIL. *Labeled "Soil from a field sixty-five years in cultivation, Daniel Everhart's farm, three miles west of Lebanon, Marion county, Kentucky. Devonian? formation."*

Color of the dried soil light-brown; darker, and of a more reddish tint than the preceding; and more like the following sub-soil. Washed with water it left 76.07 per cent. of sand, &c., of which all but 2.20 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with very few quartz grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, left nearly four and a half grains of

dark-brown extract, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.800
Alumina, oxides of iron and manganese, and phosphates,	.473
Carbonate of lime,	1.830
Magnesia,	.111
Sulphuric acid,	.036
Potash,	.053
Soda,	.077
Silica,	.098
	4.478

The air-dried soil lost 3.40 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.748
Alumina,	3.940
Oxide of iron,	4.970
Carbonate of lime,	.222
Magnesia,	.302
Brown oxide of manganese,	.312
Phosphoric acid,	.230
Sulphuric acid,	.062
Potash,	.181
Soda,	.033
Sand and insoluble silicates,	84.720
Loss,	.230
	100.000

No. 675—SUB-SOIL. *Labeled "Red sub-soil, from the field sixty-five years in cultivation, Daniel Everhart's farm, three miles west of Lebanon, Marion county Kentucky, &c."*

Color of the dried sub-soil reddish-brown; a shade lighter than that of the preceding. Washed with water it left 72.47 per cent. of sand, &c., of which all but 4.87 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *less than a grain and a half of brownish extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.110
Alumina, oxides of iron and manganese, and phosphates,	.120
Carbonate of lime,	.767
Magnesia,	.061
Sulphuric acid,	.022
Potash,	.059
Soda,	.067
Silica,	.154
	1.360

The air-dried sub-soil lost 3.20 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.679
Alumina,	4.645
Oxide of iron,	5.360
Carbonate of lime,	.297
Magnesia,	.372
Brown oxide of manganese,	.172
Phosphoric acid,	.279
Sulphuric acid,	.042
Potash,	.212
Soda,	.019
Sand and insoluble silicates,	84.720
Loss,	.202
	100.000

In these soils also, the apparent anomaly is to be noticed, of somewhat greater strength in the soil of the old field, than in that analyzed as the virgin soil. From appearances, however, it is probable that some of the sub-soil, which contains more potash than even the virgin surface soil, has been turned up by the plough and mixed with the upper soil, in the cultivation of the old field.

MEADE COUNTY.

No. 676—SOIL. *Labeled "Virgin soil, from Barren Hill Grove district, Meadville or Good Spring, Meade county, Kentucky. Primitive forest growth, black oak, black gum, hickory, post oak, white oak, black walnut; formerly "barrens," or prairie; produces much better than many blacker soils; best for corn and oats; originally covered with "barren" grass, six to eight feet high."*

Dried soil of a dusky-dark-grey color. Washed with water it left 75.6 per cent. of sand, &c., of which all but 1.4 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous and quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than a grain and a half of brownish-grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.470
Alumina, oxide of iron and phosphates,	.419
Carbonate of lime,	.233
Magnesia,	.066
Brown oxide of manganese,	.039
Sulphuric acid,	.075
Potash,	.071
Soda,	.085
Silica,	.169
	1.627

The air-dried soil lost 2.84 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.911
Alumina,	1.896
Oxide of iron,	2.040
Carbonate of lime,	.136
Magnesia,	.205
Brown oxide of manganese,	.036
Phosphoric acid,	.151
Sulphuric acid,	.041
Potash,	.259
Soda,	.042
Sand and insoluble silicates,	91.436
	100.153

No. 677—Soil. *Labeled "Same soil as the last, from an adjoining field, fifty years in cultivation in corn and oats, and sometimes wheat. For the last six years in fallow; Meadeville, Meade county, Kentucky."*

Dried soil of a dirty greyish-buff color. Washed with water it left 65.30 per cent. of sand, &c., of which all but 0.3 per cent. passed through the finest bolting-cloth. This consisted principally of rounded

quartz grains. (It is probable, that in this estimation much of the soft ferruginous particles had been rubbed up, and passed through the seive.)

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than a grain of brownish-grey extract*, dried at 212_{o} F.; which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.290
Alumina, oxide of iron and phosphates,	.098
Carbonate of lime,	.302
Magnesia,	.066
Brown oxide of manganese,	.219
Sulphuric acid,	.048
Potash,	.059
Soda,	.024
Silica,	.099
	1.205

The air-dried soil lost 2.32 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.620
Alumina,	3.136
Oxide of iron,	2.580
Carbonate of lime,	.236
Magnesia,	.298
Brown oxide of manganese,	.116
Phosphoric acid,	.125
Sulphuric acid,	.130
Potash,	.154
Soda,	.084
Sand and insoluble silicates,	91.036
	100.515

The proportion of potash in the virgin soil is quite good, and that of the phosphoric acid nearly as large as the average. Their chemical composition shows why they produce better than could be expected from their comparative light color; for, whilst they contain but a small relative proportion of organic and volatile matters, the *mineral ingredients* generally are not deficient. These soils would be improved by the use of calcareous marls, Plaster of Paris, and the ploughing in of clover, &c.

MERCER COUNTY.

No. 678—SOIL. *Labeled "Virgin soil, from woodland pasture, Col. Wm. Thompson's farm, four and a half miles south-east of Harrodsburg, Mercer county, Kentucky. Lower Silurian formation."*

Color of the dried soil light greyish-chocolate-brown. The coarse seive removed from it some cherty and ferruginous gravel. Washed with water it left 85.23 per cent. of sand, &c., of which all but 4.67 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of rounded ferruginous particles with a few of chert and quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of yellowish-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.230
Alumina, oxides of iron and manganese, and phosphates,	.813
Carbonate of lime,	2.247
Magnesia,	.190
Sulphuric acid,	.046
Potash,	.166
Soda,	.037
Silica,	.231
Loss,	.240
	5.200

The air-dried soil lost 4.50 per cent. of *moisture,* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	6.361
Alumina,	3.955
Oxide of iron,	4.050
Carbonate of lime,	.495
Magnesia,	.341
Brown oxide of manganese,	.345
Phosphoric acid,	.309
Sulphuric acid,	.076
Potash,	.144
Soda,	.024
Sand and insoluble silicates,	83.712
Loss,	.188
	100.000

No. 679—SOIL. *Labeled "Same soil as the last, Col. Wm. Thompson's farm, from a field, twenty years or more in cultivation; now in oats; Mercer county, Kentucky, &c."*

Color of the dried soil a little lighter than that of the last (No. 678.) The coarse seive removed more cherty fragments from this than from the virgin soil. Washed with water it left 84.05 per cent. of sand, &c., of which all but 6.63 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with a few of chert and quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of chestnut-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.150
Alumina, oxides of iron and manganese, and phosphates,	.963
Carbonate of lime,	2.530
Magnesia,	.083
Sulphuric acid,	.073
Potash,	.064
Soda,	.084
Silica,	.227
Loss,	.136
	5.310

The air-dried soil lost 4.00 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition*:

Organic and volatile matters,	5.208
Alumina,	3.590
Oxide of iron,	3.790
Carbonate of lime,	.385
Magnesia,	.365
Brown oxide of manganese,	.295
Phosphoric acid,	.397
Sulphuric acid,	.098
Potash,	.130
Soda,	.036
Sand and insoluble silicates,	86.250
	100.544

No. 680—SUB-SOIL. *Labeled "Sub-soil from the field, twenty years or more in cultivation, Col. Wm. Thompson's farm, Mercer county, Kentucky, &c."*

The dried sub-soil is of a little lighter and more yellowish color than the two preceding soils; it contains larger cherty and ferruginous fragments than they. Washed with water it left 84.7 per cent. of sand, &c., of which all but 7.03 per cent. passed through the finest bolting-cloth. This portion consisted of rounded ferruginous particles, with a few of chert and quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *about four grains of yellowish-grey extract*, dried at 212 F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.817
Alumina, oxides of iron and manganese, and phosphates,	.580
Carbonate of lime,	2.047
Magnesia,	.094
Sulphuric acid,	.039
Potash,	.035
Soda,	.012
Silica,	.264
Loss,	.202
	4.090

The air-dried sub-soil, dried at 400° F., lost 3.70 per cent. of *moisture*, and has the following *composition:*

Organic and volatile matters,	4.389
Alumina,	3.750
Oxide of iron,	3.415
Carbonate of lime,	.395
Magnesia,	.390
Brown oxide of manganese,	.320
Phosphoric acid,	.362
Sulphuric acid,	.050
Potash,	.114
Soda,	.040
Sand and insoluble silicates,	86.720
Loss,	.055
	100.000

The sub-soil is no richer than the surface-soil.

No. 681—Soil. *Labeled "Virgin soil, from woods, near Cornishville; lies near the rock, on the Chætetes beds of the blue limestone, overlying the birds'-eye limestone, western part of Mercer county, Kentucky. Characteristic forest growth, white oak. Lower Silurian formation."*

Dried soil in hard clods, of a light, yellowish-umber color. Washed with water it left 64.43 per cent. of sand, &c., of which all but —— per cent. passed through the fine bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than eleven grains of brownish extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.550
Alumina, oxides of iron and manganese, and phosphates,	.980
Carbonate of lime,	7.813
Magnesia,	.400
Sulphuric acid,	.061
Potash,	.077
Soda,	.100
Silica,	.114
	11.095

The air-dried soil lost 4.50 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition*, viz

Organic and volatile matters,	10.365
Alumina,	5.395
Oxide of iron,	7.110
Carbonate of lime,	1.995
Magnesia,	1.234
Brown oxide of manganese,	.620
Phosphoric acid,	.333
Sulphuric acid,	.093
Potash,	.762
Soda,	.106
Sand and insoluble silicates,	72.035
	100.000

No. 682—Soil. *Labeled "Same soil from an old adjoining field, fifty years in cultivation; now in corn; western part of Mercer county, near Cornishville, &c., &c."*

The dried soil is also in cloddy lumps; is of a lighter and more buff color than the last. Washed with water it left 67.47 per cent. of sand, &c., of which all but 8.47 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of small rounded ferruginous concretions, with a few fragments of fossil shells.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly four grains of orange-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.540
Alumina, oxides of iron and manganese, and phosphates,	.280
Carbonate of lime,	2.613
Magnesia,	.066
Sulphuric acid,	.032
Potash,	.032
Soda,	.060
Silica,	.131
	3.754

The air-dried soil lost 4.375 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	6.980
Alumina,	7.495
Oxide of iron,	7.270
Carbonate of lime,	2.080
Magnesia,	1.184
Brown oxide of manganese,	.645
Phosphoric acid,	.298
Sulphuric acid,	.090
Potash,	.705
Soda,	.106
Sand and insoluble silicates,	72.810
Loss,	.337
	100.000

No. 683—SUB-SOIL. *Labeled "Sub-soil from the old field, fifty years in cultivation, western part of Mercer county, Ky., near Cornishville. Lower Silurian formation, &c., &c."*

The dried soil is of a still lighter and more pure buff color than the two preceding; it is also in cloddy lumps; contains more decomposed

fossiliferous limestone than those soils. Washed with water, it left 57.8 per cent. of sand, &c., of which all but 6.30 per cent. passed through the finest bolting-cloth. This coarser part consisted of fragments of fossils, and rounded white and ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *more than six grains of orange-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.666
Alumina, oxides of iron and manganese, and phosphates,	.230
Carbonate of lime,	4.870
Magnesia,	·076
Sulphuric acid,	.032
Potash,	.038
Soda,	.064
Silica,	.181
	6.157

The air-dried soil lost 5.00 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	7.252
Alumina,	8.315
Oxide of iron,	7.335
Carbonate of lime,	2.850
Magnesia,	1.477
Brown oxide of manganese,	.769
Phosphoric acid,	.459
Sulphuric acid,	.058
Potash,	.650
Soda,	.050
Sand and insoluble silicates,	71.395
	100.610

No. 684—SOIL. *Labeled "Stiff under-clay, near Cornishville, western part of Mercer county, Kentucky, &c. Lower Silurian formation."*

Dried clay in hard clods of a light grey-buff color; effervesces strongly in hydrochloric acid. Washed with water it left 46.57 per cent. of sand, &c., of which all but 1.47 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small fragments of fossil shells, and rounded whitish particles, (concretions?.)

One thousand grains of the air-dried under-clay, digested for a month in water containing carbonic acid, gave up *nearly six grains of yellowish-white extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.666
Alumina, oxides of iron and manganese, and phosphates,	.053
Carbonate of lime,	4.630
Magnesia,	.061
Sulphuric acid,	.055
Potash,	.124
Soda,	.065
Silica,	.164
	5.818

The air-dried under-clay lost 4.45 per cent. of *moisture* at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	5.494
Alumina,	6.195
Oxide of iron,	5.840
Carbonate of lime,	14.170
Magnesia,	.604
Brown oxide of manganese,	.490
Phosphoric acid,	.456
Sulphuric acid,	.041
Potash,	.817
Soda,	.123
Sand and insoluble silicates,	66.245
	100.455

These soils contain an extraordinary quantity of the mineral elements of vegetable food. The under-clay is a marl of great richness, which could be used as a mineral manure on soils which are deficient in potash, lime, magnesia, the phosphates, &c. The proportions of sulphuric and phosphoric acids, in these soils, however, are not so exraordinary as those of the other essential ingredients.

No. 685—LIMESTONE. *Labeled "Limestone in and under the sub-soil of the old field (No.* 683.) *Near Cornishville, western part of Mercer county, Kentucky. Lower Silurian formation."*

Irregular fragments of a very fossiliferous dark-grey limestone.

Exterior surface softened and eroded by the action of water, &c., and changed to a dirty-buff color.

Composition, dried at 212° F.—

Carbonate of lime, - -	88.900	= 49.855 of *Lime*.
Carbonate of magnesia, -	1.468	
Alumina and oxides of iron and manganese, - - - -	2.340	
Phosphoric acid, - -	.631	
Sulphuric acid, - - -	.235	
Potash. - - - - -	.168	
Soda, - - - - -	.063	
Silex and insoluble silicates, -	7.186	
	100.981	

A limestone, of the blue limestone formation, which is very rich in the mineral ingredients of vegetable food, and which, doubtless, has furnished much of the large proportions of these materials found in the soil above it.

MORGAN COUNTY.

No. 686—COAL. *Labeled "Cannel coal, brought by the Rev. Jas. C. Crow, from his land on Clay creek, four and a half miles from the Elk fork of Licking river, and seven and a half miles west from West Liberty. Morgan county, Kentucky."*

The bed of coal from whence it was taken is represented to be 36 to 40 inches thick, with about 10 inches of shale above and below; supposed to be the next bed above the bituminous coal, 36 inches thick, found in the bed and banks of Licking river.

Quite a pure looking cannel coal of a dull black appearance, and a somewhat satiny lustre in parts; large conchoidal and laminated fracture; presenting a glimmering appearance under the microscope. Some incrustation of gypsum on the outside layer but no other visible impurities. Quite tough. No fibrous coal between the layers.

Over the spirit lamp it decrepitates a little and burns with a smokey flame, does not soften nor change its form, and leaves a hard coke of a black-lead color.

Specific gravity, - - - - - - - -	1.365

Proximate Analysis.

Moisture, - - - - -	0.80	Total volatile matters,	45.80
Volatile combustible matters, -	45.00		
Carbon in the coke, - -	32.70	Dense coke, - -	54.20
Ashes, nearly white, - -	21.50		
	100.00		100.00

The per centage of *sulphur* is 0.91.

Composition of the *ashes:*

Silica, - - - - - - - - - - - -	12.48
Alumina, with a little oxide of iron, - - - - - -	7.70
Lime, - - - - - - - - - -	.54
Magnesia, - - - - - - - - - -	.90
	21.62

One thousand grains of this cannel coal, distilled at a moderate temperature, yielded the following products, viz:

Crude oil, - - - - - - - - - -	234.00
Ammoniacal water, - - - - - - - - -	84.00
Coke, - - - - - - - - - - - -	569.00
Gas and loss, - - - - - - - - -	123.00
	1000.00

The gas measured five hundred and sixty (560) cubic inches, and possessed pretty good illuminating power.

No. 687—COAL. *Labeled "Bituminous coal, from Maj. D. Payton's land, fifteen feet above low water mark on Licking river, eight miles below West Liberty, Morgan county, Kentucky."* (*Brought by Mr. Crow.*)

The bed is said to be 36 inches thick, with ten inches of shale above and below.

A shining, deep black, pure looking coal; not soiling the fingers. Some fibrous coal between the layers. Over the spirit lamp it swelled up, and agglutinated into a bright cellular coke. Probably a coking coal.

Specific gravity, - - - - - - - - - 1.280

Proximate Anlyses:

Moisture, - - - - -	3.00	Total volatile matters,	39.60
Volatile combustible matters, -	36.60		
Carbon in the coke, - -	58.10	Cellular coke, -	60.40
Ashes—grey-purple, - -	2.30		
	100.00		100.00

The per centage of *sulphur* is 1.15. This is quite a pure coal.

No. 688—COAL. *Labeled " Cannel coal from the Rev. J. C. Crow's land, about four miles from the Elk fork of Licking river, and seven miles from West Liberty, Morgan county, Kentucky."*

Bed said to be 36 inches thick, with about ten inches of shale above and below it; at about the same level as the first described, probably another portion of the same layer.

Color a little darker than that of the first described cannel coal and with fewer minute glimmering specks; tough but breaking easily in the direction of the layers, presenting no appearance of pyrites. No fibrous coal between the layers. Weathered edges of an earthy appearance.

Over the spirit lamp it burnt with a smokey flame, did not swell up nor soften.

Specific gravity - - - - - - - - 1.360

Proximate Analysis.

Moisture,	1.90	Total volatile matters,	47.20
Volatile combustible matters,	45.30		
Carbon in the coke,	31.80	Coke, (dense,)	52.80
Ashes, yellowish-grey,	21.00		
	100.00		100.00

The per-centage of *sulphur* is 0.87.

No. 689—COAL. *Labeled "Cannel coal, from J. Barber's land, half a mile west of Elk fork of Licking river, one a half miles from its mouth, about forty feet above the bed of the branch. Morgan county, Kentucky." (Brought by the Rev. J. C. Crow.)*

Bed of coal said to be 36 inches thick with eight inches of shale above it.

A dull looking coal, easily separating into thin irregular layers, between which there is much discoloration from oxide of iron. Cross fracture somewhat satiny. The weathered edge has an earthy appearance.

Over the spirit lamp it decrepitates very slightly, burns with a smokey flame, but does not swell up nor soften.

Specific graviy, - - - - - - - - - - 1.328

Proximate Analysis :

Moisture, - - -	3.00	Total volatile matters,	43.000
Volatile combustible matters,	40.00		
Carbon in the coke, - -	44.00	Dense coke, - -	57.00
Ashes, (orange-grey,) - -	13.00		
	100.00		100.00

The per-centage of *sulphur* is 0.82.

No. 690—COAL. *Labeled "Cannel coal, from the Rev. J. C. Crow's land, three miles West of Elk fork of Licking, five miles from the mouth of Elk fork, on Mordecai creek, Morgan county, Kentucky." (Brought by Mr. Crow.)*

Bed supposed by Mr. Crow to be on the same level as the cannel coal first described, (No. 686,) about forty inches thick, with eight inches of shale above.

Deeper black, and more glossy than No. 686. Weathered end very superficially discolored by oxide of iron.

Over the spirit lamp it did not decrepitate; burnt with a smokey flame; softened and swelled up a little; the fragments cohering somewhat; and left a pretty dense coke.

Specific gravity, - - - - - - - - 1.307

Proximate Analysis :

Moisture, - - -	2.50	Total volatile matters,	43.00
Volatile combustible matters,	40.50		
Carbon in the coke, - -	48.70	Dense coke, - -	57.00
Ashes, (lilac grey,) - -	8.30		
	100.00		100.00

The per-centage of *sulphur* is 1.26.

No. 691—COAL. *Labeled "Bituminous coal, from the Rev. J. C. Crow's land, on Clay Lick fork of Licking; three miles from Elk fork, and about six miles from West Liberty, Morgan county, Ky." (Brought by Mr. Crow.)*

Coal bed represented to be sixteen inches thick, with twenty-four inches of shale below, and eight inches of ferruginous conglomerate (see No. 698,) above. Ten feet below this bed is said to be another of eight inches of coal.

A soft, bright, bituminous coal; some little pyrites between the layers, and a little fibrous coal; not soiling the fingers much; weathered surface with a little ochreous discoloration.

Over the spirit lamp it did not decrepitate; swelled up and agglutinated into a light, cellular coke; a coking coal.

Specific gravity, - - - - - - - - - 1.336

Proximate Analysis:

Moisture, - - -	3.30	Total volatile matters,	39.70
Volatile combustible matters,	36.40		
Carbon in the coke, - -	55.60	Bright cellular coke,	60.30
Ashes, (light lilac,) - -	4.70		
	100.00		100.00

The per-centage of *sulphur* is 0.74.

Composition of the *ashes :*

Silica, - - - - - - - - - - - -	1.49
Alumina, and oxide of iron, &c. - - - - -	2.88
Carbonate of lime, - - - - - - - - - -	.20
Magnesia, - - - - - - - - - - -	.17
	4.74

No. 692—Coal. *Labeled "Cannel coal, from Jesse Barber's land, one and a half miles from the mouth of Elk fork of Licking river, half a mile west of it. Morgan county, Kentucky." (Brought by Mr. Crow.)*

Bed said to be twenty-three inches thick, with ten inches of shale above it. About three feet above the level of the branch. This coal resembles No. 686, but is rather darker colored and more glossy; the fracture is splintery, not conchoidal like No. 686.

Over the spirit lamp it does not decrepitate; swells a little, but does not soften much.

Specific gravity, - - - - - - - - 1.327

Proximate Analysis :

Moisture, - - -	5.00	Total volatile matters,	42.80
Volatile combustible matters,	37.80		
Carbon in the coke, - -	46.60	Dense coke, - -	57.20
Ashes, (nearly white,) -	10.60		
	100.00		100.00

The per-centage of *sulphur* is 0.63.

No. 693—COAL. *Labeled "Bituminous coal, from Mr. Smedley's land, on the north fork of Licking river, about thirty-five feet above the bed of the creek, and about eight miles from the line of the Lexington and Big Sandy Railroad, Morgan county, Kentucky."* (*Brought by Mr. Crow.*)

The bed is said to be about thirty inches thick. A moderately soft coal, of a glossy, intense black color; breaking easily into thin layers, with much soft fibrous coal between; exterior of the layers of the weathered portion, discolored with a reddish ochreous incrustation, but no pyrites was observed.

Over the spirit lamp it decrepitated, softened, swelled up, and agglutinated into a moderately dense coke.

Specific gravity,	1.299

Proximate Analysis:

Moisture,	2.60	Total volatile matters,	39.60
Volatile combustible matters,	37.00		
Carbon in the coke,	55.40	Moderately dense coke,	60.40
Ashes, (nearly white,)	5.00		
	100.00		100.00

The per-centage of *sulphur* is 0.54.

Analysis of the Ashes:

Silica,	2.29
Alumina, oxide of iron, &c.,	2.48
Lime,	.16
Magnesia,	.14
	5.07

No. 694—COAL. *Labeled "Cannel coal, from the Rev. J. C. Crow's land, about seven miles from West Liberty, on the Big Sandy road, near Wm. Kendall's, Morgan county, Kentucky."*

The bed is represented to be about five feet above the Kendall branch of Licking river; nine inches thick, with six inches of black shale above, and twenty-four inches of yellow shale below; resembles No. 686.

Over the spirit-lamp it does not decrepitate; burns with a smokey flame, but does not soften nor change in volume. The coke was as soft as some kinds of charcoal, and may be used for drawing crayons. It is easily incinerated.

Specific gravity, - - - - - - - - - 1.542

Proximate Analysis:

Moisture, - - -	1.00	Total volatile matters,	38.60
Volatile combustible matters,	37.60		
Carbon in the coke, - -	31.40	Coke, - - -	61.40
Ashes, (light fawn colored,)	30.00		
	100.00		100.00

The per centage of *sulphur* is 1.23.

No. 695—Coal. *Labeled "Cannel coal, from John Schoolfield's land, on Mordecai creek, for miles west of West Liberty; two miles west of the Elk fork of Licking, and four miles from the mouth of Elk fork, Morgan county Kentucky."* (*Brought by Mr. Crow.*)

This cannel coal is said to be thirty inches thick, with ten inches of shale and bituminous coal (see No. 696) above it. ("Coal two feet, eight inches thick, with five inches of coal rash on the top, full of impressions of stigmaria."—(*Dr. Owen's Notes.*)

A deep black coal, with but little lustre; breaking in layers, which have no fibrous coal between.

Over the spirit-lamp it does not decrepitate; but softened and swelled a little; the fragments did not agglutinate; left a moderately dense coke.

Specific gravity, - - - - - - - - - 1.288

Proximate Analysis:

Moisture. - - -	1.40	Total volatile matters,	45.80
Volatile combustible matters,	44.40		
Carbon in the coke, -	48.00	Moderately dense coke,	54.20
Ashes, (light buff,) - -	6.20		
	100.00		100.00

The per centage of *sulphur* is 0.68.

Composition of the ashes:

Insoluble silicates, - - - - - - - - -	3.19
Alumina, oxides of iron and manganese, - - - - -	1.99
Carbonate of lime, - - - - - - - -	.28
Magnesia, - - - - - - - - - - -	.33
Potash, - - - - - - - - - - -	.15
Soda, - - - - - - - - - - -	.07
Loss, - - - - - - - - - - -	.19
	6.20

In order to ascertain the presence of the alkalies in these ashes they were analyzed by digestion in hydrochloric acid, &c., instead of by fusion with the mixed alkaline carbonates, &c., as is usually done. It will be seen that they contain a fair proportion of alkaline matter; they were not tested for the presence of phosphoric acid.

After the above analyses were completed on the small specimens brought to the Laboratory by Mr. Crow, Mr. Schoolfield sent a large piece of this coal, and I was enabled to submit it to the process of distillation.

One thousand grains of this cannel coal, distilled at a low red heat, gave the following products, viz:

Crude oil, thin and dark colored,	176.00
Ammoniacal water, (black,)	82.00
Slightly coherent coke,	642.00
Gas and loss,	100.00
	1000.00

The gas measured three hundred and ninety cubic inches, and had moderate illuminating powers. It is therefore not remarkable amongst the oil-producing coals. (See table at the end of the preceding volume.)

No. 696—COAL. *Labeled "Bituminous coal, lying on the preceding. Morgan county, Kentucky." Brought by Mr. Crow."*

A bright, soft, bituminous coal, a little fibrous coal and pyrites between the layers into which it easily separates. Discolored, on the surface, with clay and oxide of iron.

Over the spirit-lamp it swelled up a good deal, softening and agglutinating.

Specific gravity, ... 1.345

Proximate Analysis.

Moisture,	3.00	Total volatile matters,	42.60
Volatile combustible matters,	39.60		
Carbon in coke,	48.20	Cellular coke,	57.40
Ashes, (lilac color,)	9.20		
	100.00		100.00

The per centage of *sulphur* is 4.84.

Composition of the ash:

Silex and insoluble silicates, - - - - - - - -	2.19
Alumina, and oxides of iron and manganese, - - - -	6.48
Lime, a trace.	
Magnesia, - - - - - - - - - - - - -	.33
Potash, - - - - - - - - - - - - -	.17
Soda, - - - - - - - - - - - - -	.13
	9.20

No.697—COAL. *Labeled "Bituminous coal, from Wm. Kendall's land on the Sandy road,* 6 *miles from West Liberty, Morgan county, Kentucky." Brought by Mr. Crow.*

Bed said to be fifteen inches thick. A soft, pure-looking, bright, bituminous coal, with no fibrous coal or pyrites between the layers.

Over the spirit-lamp it softens very much, and swells up into a very cellular coke.

Specific gravity, - - - - - - - - - 1.296

Proximate Analysis.

Moisture, - - - - -	2.70	Total volatile matters,	45.60
Volatile combustible matters, -	42.90		
Carbon in the coke, - -	50.40	Bright cellular coke,	54.40
Ashes, (dull lilac colored,) -	4.00		
	100.00		100.00

The per centage of *sulphur* is 2.42.

No. 698—LIMONITE, (IMPURE.) *Labeled "Ferruginous conglomerate, lying above the coal No.* 691, *on the Rev. J. C. Crow's land, Morgan county, Kentucky."*

General color rust-brown and yellowish. A sandy conglomerate of flattened rounded pebbles of ferruginous mineral, united by a sandy ferruginous cement. Powder of a brownish-yellow color.

Composition, dried at 212° F.—

Oxide of iron, - - -	22.04	= 22.10 per cent. of *Iron*.
Carbonate of iron, - -	15.34	
Carbonate of lime, - -	1.64	
Carbonate of magnesia, -	2.92	
Carbonate of manganese, -	1.02	
Alumina, - - - - -	.81	
Phosphoric acid, - - -	.37	
Sulphur, - - - - -	.27	

Potash, - - - - -	.17
Soda, - - - - -	.31
Silex and insoluble silicates, -	54.48
Water and loss, - - -	.63
	100.00

Too poor in iron to be profitably smelted by itself, it yet might be used to mix with richer ores to furnish silicious material for the flux, and the formation of cinder, in the high furnace.

No. 699—SANDSTONE, (FERRUGINOUS.) *Labeled "Iron ore? common on the tops of the hills, in the south-western part of Morgan county, Kentucky." Brought by Mr. Crow.*

A fine-grained, compact, ferruginous sandstone, showing numerous small scales of mica, color shading from light red to brownish red. Powder of a venetian red color.

Composition:

Sand and insoluble silicates, - - - - - - -	84.38
Oxide of iron, and alumina, - - - - - - -	12.78
Carbonate of lime, - - - - - - - - - -	1.76
Magnesia, water, and loss, - - - - - - - -	1.08
	100.00

(See Rowan county for some other minerals of this region.)

MUHLENBURG COUNTY.

No. 700—SHALE, (BITUMINOUS.) *Labeled "Bituminous shale on the land of Messrs. Martin. Hawe Ridge, one and a half miles north-west of Greenville, waters of Caney creek. Muhlenburg county, Kentucky." Brought by Mr. Martin.*

Bed said to be two to four feet thick. Shale of a dull black color, separating into thin layers, which are stained in parts with oxide of iron and covered with small crystals of sulphate of lime. Decrepitates in the fire.

Proximate Analysis.

Total volatile matters, - - - - - - - - -	25.00
Fixed carbon, - - - - - - - - - -	30.50
Yellowish-grey earthy residue, - - - - - - -	44.50
	100.00

No. 701—SHALE, (BITUMINOUS.) *From same locality as the last. Muhlenburg county, Kentucky.*

Color darker than that of the last, free from ochreous incrustation.

Proximate Analysis.

Total volatile matters,	41.50
Fixed carbon,	38.50
Grey earthy residue,	21.00
	100.00

No. 702—SHALE, (BITUMINOUS.) *From the same locality as the preceding. Muhlenburg county, Kentucky.*"

Resembles the preceding.

Proximate Analysis.

Total volatile matters,	40.20
Fixed carbon,	31.80
Grey earthy residue,	28.00
	100.00

These two latter specimens approach cannel coals in composition and properties; whether these could be profitably distilled for the manufacture of the *coal oils*, &c., might be ascertained by calculations based on the relative quantity of these products which they would yield, proximity to market, &c., &c. A sufficient quantity of the shales was not brought to the Laboratory to enable me to institute the necessary experiments.

No. 703—SHALE, (BITUMINOUS.) *From the same locality as the preceding. Muhlenburg county, Kentucky.*"

Dull black color, not soiling the fingers.

Proximate Analysis.

Moisture,	4.30
Volatile and combustible matters,	23.10
Fixed carbon,	35.50
Yellowish-grey earthy residue,	37.10
	100.00

No. 704—CARBONATE OF IRON, (BITUMINOUS.) *Labeled "Black Band Iron Ore. Roof of the upper coal. Airdrie Furnace. Muhlenlenburg county, Kentucky. (Estimate the sulphur.)"*

A dull, fine-granular ore, adhering to the tongue on the cross fractures, separating easily into irregular laminæ, which are nearly black on the exterior, and dark umber-colored on the cross-fracture, which presents parallel lines of darker and lighter color. Powder mouse-colored.

Specific gravity, - - - - - - - - - 2.959

Composition, dried at 212° F.—

Carbonate of iron, - -	59.344	= 31. 598per cent. of *Iron*.
Oxide of iron, - - -	4.180	
Alumina, - - -	2.290	
Carbonate of lime, - -	3.390	
Carbonate of Magnesia, -	7.149	
Carbonate of manganese, -	2.017	
Phosphoric acid, - -	.428	
Sulphur, - - -	.246	
Potash, - - - -	.286	
Soda, - - - -	.322	
Bituminous matter, - -	4.071	
Silex and insoluble silicates, -	16.280	
	100.000	

The air-dried ore lost 0.54 per cent. of *moisture* at 212° F.

No. 705—LIMESTONE. *Labeled "Limestone, found five feet thick above the six feet coal; used for flux at Airdrie Furnace. Muhlenburg county, Kentucky."*

A dark-grey, compact, fine granular limestone, containing irregular specks and veins of discolored calcareous spar, minute microscopical specks of golden yellow pyrites, and effloresced sulphate of iron in places. Powder of a light-grey color.

Specific gravity, - - - - - - - 2.777

Composition, dried at 212° F.—

Carbonate of lime, - - -	82.880	= 46.509 per cent. of *Lime*.
Carbonate of magnesia, - -	4.196	
Alumina, and oxides of iron and manganese, - - -	4.333	
Phosphoric acid, - - -	.247	

Sulphuric acid, - - -	4.717	— 1.891 per cent. of *Sulphur*.
Potash, - - - - - -	.135	
Soda, - - - - - -	.150	
Silex and insoluble silicates, -	4.280	
	100.938	

The unusually large proportion of sulphur contained in this limestone, renders it objectionable as a flux for iron ore; and mainly to the use of this limestone at the Airdrie Furnace, may be attributed the singular appearance of a considerable amount of sulphuret of iron, which flows out with the slag, and the too large proportion of sulphur contained in the pig iron, (see No. 707,) notwithstanding the use of a great excess of limestone for the flux. (See next analysis of the slag.) The sulphur in this limestone, although it is stated as sulphuric acid in the account of the analysis above, no doubt exists in the rock principally in combination with iron, as bi-sulphuret of iron, or yellow iron pyrites, minute specks of which can be seen in it by the aid of the microscope. This limestone would answer admirably for agricultural purposes, for the improvement of exhausted soil, or land deficient in phosphoric acid, sulphuric acid, or the alkalies; but could a purer specimen of limestone be found for use as flux at the Airdrie Furnace, the quality of the iron might possibly be improved. The coal, however, which is used in the *raw*, or uncoked condition at this furnace, also contains sulphur, (1.35 per cent. or more,) as does the ore employed, (0.246 per cent.—see preceding analysis.)

No. 706—Iron Furnace Slag. *Labeled "Airdrie Furnace slag. Furnace running raw coal, and using the hot blast. Muhlenburg county, Kentucky."*

An opake, dense, slag; free from air-bubbles; drab-colored in the interior; bluish on the exterior; melting easily before the blow-pipe, with intermescence into a white, blebby glass.

Composition:

Silica, - - - - -	42.080	containing of oxygen,		21.849
Alumina, - - - - -	23.080	" "	10.788	
Lime, - - - - -	24.230	" "	6.890	
Magnesia, - - -	6.103	" "	2.439	
Protoxide of manganese, -	1.023	" "	.230	
Prtoxide of iron, - -	1.044	" "	.231	
Potash, - - - - -	2.066	" "	.345	
Soda, - - - - -	.599	" "	.153	
	100.225		21.076	: 21.849

Oxygen on the bases to oxygen in the silica, as 1 : 1.036

It will be seen by comparison of this analysis with those of slags from the iron furnaces where charcoal is used as the fuel, in the first and second volumes of this report, that there it contains nearly twice as much lime as those; and that, moreover, the proportion of the bases generally, to the silica, is nearly twice as great in this slag as in the slags from the charcoal furnaces. The slag, however, seems to be a sufficiently fusible one, especially as the hot blast is used; and the use of a large amount of lime tends to remove much of the sulphur present, and prevents it from combining with the metal, especially when the limestone which is employed as flux, does not itself contain much of that element.

No. 706, (*a*)—SLAG. *Accompanying this slag, was a specimen labeled "Rough slag. Airdrie Furnace, Muhlenburg county, Kentucky." Is the bright metallic looking substance sulphuret of iron?*

This singular product is a conglomerate, of a bright, light yellow, metallic-like substance, involving a dull, brownish-black, dull, porous material. The bright substance is brittle, and attracted by the magnet; it has a lamellar fracture, and the fresh surfaces are nearly white, and of a high metallic lustre. Before the blow-pipe it melted unchanged at a high temperature, gradually evolving sulphur. It dissolves in hydrochloric acid, with the copious evolution of sulphuretted hydrogen gas.

Specific gravity, - - - - - - 6.818

It is therefore a sulphuret of iron, containing much proto-sulphuret, and is a very singular product of the iron furnace. It flows out from the furnace with the ordinary slag, or cinder.

No. 707—Pig Iron. *Labeled "Airdrie Furnace Pig Iron, made with raw stone coal, and hot blast. Muhlenburg county, Kentucky."*

A fine-grained, light-colored iron, which yields readily to the file and is easily crushed to powder under the hammer, when in small fragments.

Specific gravity, - - - - - - 7.0067

Composition:

Iron,	88.428		
Graphite	1.360	Total carbon, -	1.550
Combined carbon,	.190		
Manganese,	.980		
Silica,	6.216		
Slag,	3.090		
Aluminium,	.099		
Magnesium,	.309		
Potassium,	.059		
Sodium,	.091		
Phosphorus,	.209		
Sulphur,	.219		
	101.250		

This iron contains more slag and sulphur than any of the pig irons from the charcoal furnaces which have been examined, and a very large proportion of silicon—as large as is to be found in any of them, which, as well as the sulphur, tends to make the iron "*hot short.*" The very large proportion of slag and silicon present, is doubtless owing to the very high temperature produced by the hot blast, and these ingredients are readily removed from the iron, in the operation of puddling, to convert it to malleable iron. The sulphur is not quite so easily separated, but would not be very objectionable in cast iron or railroad iron. The probability is, that the iron smelted with stone coal and the hot blast, can never compete with the best charcoal iron, for the manufacture of the finest and toughest bar iron and steel. Yet it is applicable to castings, and to the manufacture of railroad iron, and to other common purposes. *Cheap iron*, in short, is of very extensive application, in this and in all civilized countries, and its manufacture in our coal districts, is a great desideratum, especially in view of the large amount of capital annually sent to Europe to procure it.

Since the foregoing analyses were made, a collection of very fine specimens of the black band ore, (upper, middle, and bottom portions,)

some of the roasted ore; pig iron of the first run; limestone used as flux, and of the coal, from Airdrie Furnace, were sent to this laboratory by the enterprising proprietor, Mr. Alexander. They arrived too late, however, for chemical examination before the preparation of this report, and will be deposited at the State Cabinet at Frankfort.

NELSON COUNTY.

No. 708—CARBONATE OF IRON. *Labeled "Kidney iron ore two miles south-east of New Haven, at James Bell's, in the Knobs. Sub-carboniferous sandstone. Nelson county, Kentucky."*

A fine granular, dark brownish-grey mineral, becoming more brown towards the exterior; not adhering to the tongue. Powder of a dark buff-grey color.

Dried at 212°, the air-dried mineral lost 0.50 per cent. of *moisture.*

Specific gravity, - - - - - - - - - 5.201

Composition, dried at 212° F.—

Carbonate of iron, - -	53.50	= 29.69 per cent. of *Iron*
Oxide of iron. - - -	5.50	
Carbonate of lime, - -	4.58	
Carbonate of magnesia, -	9.82	
Carbonate of manganese, -	.71	
Alumina, - - -	3·15	
Phosphoric acid, - . -	.63	
Sulphur, - - -	.08	
Potash, - - - - -	.48	
Soda, - - - - -	.23	
Silex and insoluble silicates, -	21.48	
	100.16	

No doubt rich enough for profitable smelting. It would require little or no limestone for flux.

No. 709—LIMESTONE, (MAGNESIAN.) *Labeled "Magnesian building stone. Bardstown, Nelson county, Kentucky. Upper Silurian formation."*

A grey-buff, fine-granular rock; not adhering to the tongue. Under the lens appearing to be made up of pretty pure crystalline grains. Powder of a light grey color.

The air-dried powdered stone lost only 0.10 per cent. of *moisture* at 212° F.

Specific gravity, - - - - - - - - - - 2.758

Composition, dried at 212° F.—

Carbonate of lime, - -	62.19	— 34.90 per cent. of *Lime*.
Carbonate of magnesia, - -	33.90	
Alumina, and oxides of iron and manganese, and trace of phosphates, - - - - -	.68	
Potash, - - - - -	.46	
Soda, - - - - - -	.35	
Silex and insoluble silicates, -	3.18	
	100.76	

This magnesian limestone was found to contain only a very small trace of *sulphur*. It does not differ greatly in composition from the limestone rocks of the lower strata of the Lower Silurian formation, and will doubtless be found *a very durable* building material.

No. 710—CARBONATE OF IRON. *Labeled "Grey kidney ore. (Sub-carboniferous sandstone formation.) Nelson Furnace, Nelson county, Kentucky."*

A fine-grained, dull, grey ore; not adhering to the tongue. Exterior layer yellowish-brown; adhering to the tongue. Powder, of the interior portion, buff-grey.

Specific gravity, - - - - - - - - - - 3.348

The air-dried powdered ore lost 0.50 per cent. of *moisture* at 212°F.

Composition, dried at 212° F.—

Carbonate of iron, - -	69.96	} — 35.64 per cent. of *Iron*.
Oxide of iron, - - -	2.64	}
Carbonate of lime, - -	3.98	
Carbonate of magnesia, - -	9.43	
Carbonate of manganese, -	1.32	
Alumina, - - - - -	1.55	
Phosphoric acid, - - -	.63	
Sulphur, - - - - -	.09	
Potash, - - - - -	.34	
Soda, - - - - -	.34	
Silex and insoluble silicates, -	10.48	
	100.76	

A good and sufficiently rich ore of iron, which will require little or no limestone to flux it. The proportion of phosphoric acid which it contains, however, is a little greater than is desirable.

No. 711—LIMESTONE. *Labeled "Limestone used as a flux at Nelson Furnace, Devonian formation? Nelson county, Kentucky."*

A fine-granular, grey-buff limestone; with no appearance of fossils. Weathered surface brownish. Some small cavities in it.

The air-dried powdered limestone lost 0.50 per cent. of *moisture* at 212° F.

Composition, dried at 212° F.—

Carbonate of lime, - -	51.66—	29. per cent. *Lime.*
Carbonate of Magnesia, -	32.00	
Alumina and oxide of iron, &c.,	5.55	
Sulphuric acid, - - - -	.09	
Potash, - - - - -	.77	
Soda, - - - - - -	.46	
Silex and insoluble silicates, -	9.78	
	100.31	

No. 712—IRON FURNACE SLAG. *Labeled "Green slag. Nelson Furnace, Nelson county, Kentucky."*

Dull olive-green, at one end of the fragment, passing into dull yellowish at the other. Translucent in the thin pieces and on the thin edges of the yellowish portion.

Before the blow-pipe it melted pretty readily into a blebby globule.

Composition:

Silica, - - - - -	53.524	containing of	oxygen,		27.793
Alumina, - - - - -	19.957	"	"	9.328	
Lime, - - - - -	14.000	"	"	3.982	
Magnesia - - - - -	5.706	"	"	2.280	
Protoxide of iron, - -	2.673	"	"	.593	
Protoxide of manganese, -	.059	"	"	.013	
Potash, - - - - -	3.244	"	"	.550	
Soda, - - - - -	1.401	"	"	.359	
	100.564			17.105	: 27.793

The oxygen in the *bases* is to the oxygen in the *silica* as, 1 : 1.624

The use of a little more limestone for the flux might make the cinder more fusible, and remove from it the nearly two per cent. of protoxide of iron which it contains, and which is so much loss.

No. 713—Pig Iron. *Labeled "Pig iron from Nelson Furnace, Nelson county, Kentucky."*

A moderately fine grained, grey iron. It flattens considerably under the hammer and yields easily to the file.

Specific gravity,	7.1493
Composition:	
Iron,	95.173
Graphite,	2.880
Silicon,	.697
Slag,	.190
Manganese,	.274
Aluminium,	.101
Calcium,	.025
Magnesium,	.114
Potassium,	.096
Sodium,	.026
Sulphur.	.339
Phosphorus,	.096
	100.011

This is quite a soft iron, which does not seem to contain any *combined carbon.* Its proportion of sulphur is considerable, otherwise it is quite a pure specimen of Pig iron.

No. 714—Soil. *Labeled "Virgin soil, woods pasture; Mr. Beauchamp's land on Chaplin creek. Lower Silurian formation. Primitive forest growth, sugar-tree, beech, and blue ash. (Mr. B. says it will not produce well if sub-soiled.) Nelson county, Kentucky."*

Dried soil of a light umber color. Washed with water it left 86.53 per cent. of sand, &c., of which all but 4.07 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles or concretions.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly six grains of chestnut-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.333
Alumina, oxides of iron and manganese, and phosphates,	1.297
Carbonate of lime,	2.630
Magnesia,	.123
Sulphuric acid,	.068
Potash,	.150
Soda,	.077
Silica,	.177
	5.855

The air-dried soil lost 4.985 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	6.659
Alumina,	4.655
Oxide of iron,	4.065
Carbonate of lime,	.770
Magnesia,	.452
Brown oxide of manganese,	.395
Phosphoric acid,	.535
Sulphuric acid,	.093
Potash,	.222
Soda,	.026
Sand and insoluble silicates,	82.195
	100.067

No. 715—Soil. *Labeled "Same soil as preceding, from a field thirty-three years in cultivation, that has been injured by sub-soiling. (More beech grew on this than on the preceding soil.) Mr. Beauchamp's farm, &c., Nelson county, Kentucky."*

Dried soil of a lighter color, and more yellowish than the preceding. Washed with water it left 75.40 per cent. of sand, &c., of which all but 3.60 per cent. passed through the fine bolting-cloth. This coarser portion consists of small rounded ferruginous particles, with a few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *not quite two grains and a half of light-brown extract,* dried at 212° F., of the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.417
Alumina, oxides of iron and manganese, and phosphates,	.313
Carbonate of lime,	1.130
Magnesia,	.111
Sulphuric acid,	.026
Potash,	.149
Soda,	.043
Silica,	.200
	2.389

The air-dried soil lost 2.70 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.423
Alumina,	3.140
Oxide of iron,	2.825
Carbonate of lime,	.330
Magnesia,	.282
Brown oxide of manganese,	.280
Phosphoric acid,	.316
Sulphuric acid,	.078
Potash,	.130
Soda,	.036
Sand and insoluble silicates,	88.895
Loss,	.265
	100.000

No. 716—SUB-SOIL. *Labeled "Sub-soil, from the same field, thirty-three years in cultivation; that has never been turned up. Mr. Beauchamp's farm, Chaplin creek, Nelson county, Kentucky."*

Dried sub-soil of a greyish-buff color. Washed with water it left 78.93 per cent. of sand, &c., of which all but 2.07 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *rather more than one and a half grains of grey-buff extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.340
Alumina, oxides of iron and manganese, and phosphates,	.187
Carbonate of lime,	.740
Magnesia,	.066
Sulphuric acid,	.022
Potash,	.074
Soda,	.053
Silica,	.097
	1.579

The air-dried soil lost 2.85 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.804
Alumina,	3.490
Oxide of iron,	3.370
Carbonate of lime,	.230
Magnesia,	.254
Brown oxide of manganese,	.220
Phosphoric acid,	.277
Sulphuric acid,	.059
Potash,	.101
Soda,	.034
Sand and insoluble silicates,	88.970
Loss,	.191
	100.000

The reason why the intermixture of the sub-soil injures the fertility of the surface-soil of these fields is to be readily observed in the smaller proportion of lime, magnesia, oxide of manganese, phosphoric acid, sulphuric acid, and of potash, as well as of alumina and oxide of iron, contained in the sub-soil, and its larger proportion of sand and silicates, and in the much smaller quantity of soluble matter which it gives up to water containing carbonic acid. The organic and volatile matter is also in much smaller amount in it, but this is usually the case with sub-soil as compared with the more superficial stratum.

No. 717—SOIL. *Labeled "Under-earth overlying the shell and coralline beds, (of Lower Silurian formation;) very loose; considered by Mr. Beauchamp injurious to the surface-soil. Mr. Beauchamp's land, on Chaplin creek. Nelson county, Kentucky."*

Dried soil of a rather darker grey-buff color than the preceding. The coarse seive removed from it some fragments of rotten sandstone. Washed with water, it left 79.37 per cent. of sand, &c., of which all but 10.5 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *a little more than a grain and a half of light-grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.583
Alumina, oxides of iron and manganese, and phosphates,	.038
Carbonate of lime,	.630
Magnesia,	.029
Sulphuric acid,	.016
Potash,	.037
Soda,	.060
Silica,	.177
	1.620

The air-dried soil lost 5.575 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.090
Alumina,	8.240
Oxide of iron,	7.065
Carbonate of lime,	1.725
Magnesia,	.731
Brown oxide of manganese,	.380
Phosphoric acid,	.438
Sulphuric acid,	.059
Potash,	.334
Soda,	.052
Sand and insoluble silicates,	77.275
	100.389

A soil containing so much organic and volatile matters, such large proportions of alumina and oxide of iron, of lime, magnesia, and phos-

phoric acid, with more than the average quantity of potash, would be generally considered a *fertile* soil, if there was nothing in its physical (or mechanical) properties unfavorable to vegetable growth. The proportion of sulphuric acid will be seen, however, to be quite small, and it will be observed that, although it contains, in large proportion, most of the elements necessary for vegetable nourishment, especially a large amount of lime and magnesia, which are quite soluble in water charged with carbonic acid, *it gives up but a comparatively small amount of soluble extract, when digested in that fluid*, of which more than a third is carbonate of lime. It seems to contain the mineral elements necessary to vegetable growth in sufficient amount therefore, but not much of them in *a soluble state*. Whether the application of caustic slacked lime to this soil might change this condition of things is well worthy a trial. The use of Plaster of Paris to furnish sulphuric acid might be followed by good results.

No. 718—UNDER-EARTH, "*with fragments of Orthis lynx; road near Mr. Beauchamp's, on Chaplin creek, Nelson county, Kentucky. Lower Silurian formation.*"

Dried soil of a dirty-buff color. The coarse seive removed from it a few fragments of fossil shells. Washed with water it left 66.30 per cent. of sand, &c., of which all but 10.03 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *a little more than a grain and a half of yellowish-grey extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.283
Alumina, oxides of iron and manganese, and phosphates,	.147
Carbonate of lime,	.977
Magnesia,	.070
Sulphuric acid,	.036
Potash,	.041
Soda,	.061
Silica,	.131
	1.746

The air-dried soil lost 5.05 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.449
Alumina,	7.290
Oxide of iron,	6.015
Carbonate of lime,	.520
Magnesia,	.967
Brown oxide of manganese,	.295
Phosphoric acid,	.368
Sulphuric acid,	.033
Potash,	.283
Soda,	.058
Sand and insoluble silicates,	79.730
	100.008

This soil strikingly resembles the next preceding one in properties and composition. Like that it has all the elements of fertility in more than the average proportions, except that the sulphuric acid is deficient, yet gives up but a very small amount, comparatively, of soluble extract, when it is digested in water charged with carbonic acid, indicating that although rich in the nourishing elements it yields them very sparingly to growing crops. (See remarks on the preceding soil.)

No. 719—Soil. *Labeled "Virgin soil, over the Calymene Blumenbachii bed of magnesian limestone. Five miles south-west of Bardstown; Cedar creek meeting-house, Nelson county, Kentucky. Upper Silurian formation."*

Dried soil of a greyish-buff color. The coarse seive removed from it some small irregular fragments of a soft ferruginous sandstone. Washed with water it left 79.92 per cent. of sand, &c., of which all but 6.20 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles with a few of quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly five grains of light chesnut-brown extract,* dried at 212° F., which has the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.263
Alumina, oxides of iron and manganese, and phosphates,	.803
Carbonate of lime,	2.177
Magnesia,	.139
Sulphuric acid,	.055
Potash,	.074
Soda,	.035
Silica,	.270
	4.816

The air-dried soil lost 3.75 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition*, viz:

Organic and volatile matters,	5.298
Alumina,	3.890
Oxide of iron,	3.875
Carbonate of lime,	.270
Magnesia,	.416
Brown oxide of manganese,	.420
Phosphoric acid,	.114
Sulphuric acid,	.051
Potash,	.098
Soda,	.036
Sand and insoluble silicates,	85.895
	100.363

This soil gives a striking contrast to the two preceding soils, for although it contains much less of the fertilizing ingredients generally, and but a little more of organic and volatile matters, it gives up about three times as much soluble matter to the water charged with carbonic acid, in which it is digested.

No. 720—Soil. *Labeled "Virgin soil, Guthry farm, near Bloomfield, Nelson county, Kentucky. Lower Silurian formation. Blue ash land."*

Dried soil of a brownish-buff color. Washed with water the soil left 84.63 per cent. of sand, &c., of which all but 3.30 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of yel-*

lowish-brown extract, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.450
Alumina, oxides of iron and manganese, and phosphates,	.881
Carbonate of lime,	2.207
Magnesia,	.100
Sulphuric acid,	.048
Potash,	.101
Soda,	.047
Silica,	.198
	5.032

The air-dried soil lost 3.425 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.384
Alumina,	4.280
Oxide of iron,	3.905
Carbonate of lime,	.405
Magnesia,	.492
Brown oxide of manganese,	.470
Phosphoric acid,	.228
Sulphuric acid,	.117
Potash,	.193
Soda,	.049
Sand and insoluble silicates,	84.395
Loss,	.082
	100.000

No. 721—Soil. *Labeled "Same soil, from the Guthry farm, forty years in cultivation; blue ash land. Lower Silurian formation. Nelson county, Kentucky."*

Color of the dried soil brownish-buff; slightly lighter than that of the preceding; some fragments of fossil shells were removed from it with the coarse seive. Washed with water it left 82.83 per cent. of sand, &c., of which all but 5.5 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous and cherty particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly four grains of chesnut-*

brown extract, dried at 212 F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.150
Alumina, oxides of iron and manganese, and phosphates,	.847
Carbonate of lime,	1.473
Magnesia,	.070
Sulphuric acid,	.073
Potash,	.071
Soda,	.058
Silica,	.100
	3.842

The air-dried soil, lost 3.25 per cent. of *moisture* at 400° F., dried at which temperature it had the following *composition:*

Organic and volatile matters,	4.858
Alumina,	4.070
Oxide of iron,	3.795
Carbonate of lime,	.222
Magnesia,	.553
Brown oxide of manganese,	.295
Phosphoric acid,	.351
Sulphuric acid,	.067
Potash,	.268
Soda,	.015
Sand and insoluble silicates,	85.585
	100.079

No. 722—SUB-SOIL. *Labeled "Sub-soil from the same old field; Guthry farm; Nelson county, Kentucky, &c., &c.*

Dried sub-soil of a dirty-buff color; lighter than that of the two preceding soils. Washed with water it left 66.27 per cent. of sand, &c., of which all but 5.82 per cent. passed through the finest bolting-cloth. This coarser portion consisted of ferruginous and cherty particles.

One thousand grains of the air-dried sub-soil, digested for a month in water containing carbonic acid, gave up *two grains of umber-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.666
Alumina, oxides of iron and manganese, and phosphates,	.196
Carbonate of lime,	.800
Magnesia,	.068
Sulphuric acid,	.064
Potash,	.044
Soda,	.043
Silica,	.121
	2.000

The air-dried sub-soil lost 4.00 per cent. of *moisture*, at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	4.088
Alumina,	5.910
Oxide of iron,	5.160
Carbonate of lime,	.336
Magnesia,	.487
Brown oxide of manganese,	.320
Phosphoric acid,	.345
Sulphuric acid,	.085
Potash,	.275
Soda,	.055
Sand and insoluble silicates,	83.210
	100.271

No. 723—SHELL-EARTH. *Labeled "Under Orthis lynx earth, side of the road, on Guthry's farm. Lower Silurian formation. Nelson county, Kentucky."*

Dried soil of a dirty-buff color; some fragments of fossil shells were removed from it by the coarse seive. Washed with water it left 82.83 per cent. of sand, &c., of as much as 21.43 per cent. was too coarse to pass through the fine bolting-cloth. This portion consisted of small fragments of fossil shells, and rounded ferruginous and cherty particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *less than two grains of brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.830
Alumina, oxides of iron and manganese, and phosphates,	.230
Carbonate of lime,	.547
Magnesia,	.039
Sulphuric acid,	.060
Potash,	.039
Soda,	.080
Silica,	.131
	1.956

The air-dried soil lost 5.275 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	6.281
Alumina,	9.325
Oxide of iron,	7.885
Carbonate of lime,	.645
Magnesia,	1.100
Brown oxide of manganese,	.295
Phosphoric acid,	.773
Sulphuric acid,	.062
Potash,	.449
Soda,	.272
Sand and insoluble silicates,	73.095
	100.182

This latter shell earth resembles that previously described, from Mr. Beauchamp's land on Chaplin creek, Nelson county, (Nos. 717 and 718.) They all contain large proportions of alumina and oxide of iron, much organic and volatile matters, and much more than the usual amount of lime, magnesia, phosphoric acid, and potash, but contain a very moderate quantity of sulphuric acid, and *give but a very small amount of soluble matters to the water charged with carbonic acid.*

In the soils from the Guthry farm, that from the old field appears to contain more of these essential mineral elements than the virgin soil, but much less of them in the *soluble form.* The sub-soil, which has probably been mixed with the surface-soil somewhat, during the cultivation of the field, partakes of the same characters.

No. 724—SOIL. *Labeled "Virgin soil, from Maj. Minor's woods-pasture. Primitive forest growth, large poplar, blue ash and beach. Near Bloomfield. Lower Silurian formation. Nelson county, Ky."*

Color of the dried soil, dirty buff. Washed with water it left 79.41 per cent. of sand, &c., of which all but 3.47 per cent. passed through the fine bolting-cloth. This portion consisted of small rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly six grains of brownish extract,* dried at 212° F.; which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.700
Alumina, oxides of iron and manganese, and phosphates,	.964
Carbonate of lime,	2.563
Magnesia,	.013
Sulphuric acid,	.164
Potash,	.170
Soda,	.054
Silex,	.264
	5.892

The air-dried soil lost 2.575 per cent. of *moisture,* at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	7.195
Alumina,	3.295
Oxide of iron,	3.110
Carbonate of lime,	.445
Magnesia,	.522
Brown oxide of manganese,	.195
Phosphoric acid,	.342
Sulphuric acid,	.096
Potash,	.154
Soda,	.021
Sand and insoluble silicates,	84.595
Loss,	.030
	100.000

No. 725—Soil. *Labeled "Soil from Maj. Miner's field, fourteen years in cultivation. Near Bloomfield, Nelson county, Ky. Lower Silurian formation, &c., &c."*

Dried soil of a dirty-buff color. Washed with water it left 84.80 per cent. of sand, &c., of which all but 5.77 per cent. passed through the fine bolting-cloth. This coarser portion consisted of rounded ferruginous particles, pieces of fossils and chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly five grains of chestnut-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.660
Alumina, oxides of iron and manganese, and phosphates,	.847
Carbonate of lime,	3.040
Magnesia,	.083
Sulphuric acid,	.045
Potash,	.054
Soda,	.027
Silica,	.139
	4.895

The air-dried soil lost 2.64 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	7.164
Alumina,	3.495
Oxide of iron,	3.535
Carbonate of lime,	.520
Magnesia,	.656
Brown oxide of manganese,	.220
Phosphoric acid,	.343
Sulphuric acid,	.067
Potash,	.125
Soda,	.027
Sand and insoluble silicates,	83.770
Loss,	.078
	100·000

The fourteen years cultivation of this field, has not caused much deterioration. The quantities of organic and volatile matters, lime,

magnesia, and phosphoric acid, are pretty much the same in this and in the virgin soil. The soil of this cultivated field gives less soluble matter to the water charged with carbonic acid, however, and contains a smaller quantity of potash and sulphuric acid.

No. 726—MARL. *Labeled "Mathers marl, or ash colored clay, containing carbonate of lime; from the deep cut in the Bardstown turnpike; two and a half to three miles from New Haven, Nelson county, Kentucky. Sub-carboniferous formation."*

A yellowish-grey, stratified indurated clay, or soft shale. Powder of a light olive-grey color.

Composition, dried at 212° F.—

Alumina, oxides of iron, and manganese,	11.850
Carbonate of lime,	.393
Magnesia,	.966
Phosphoric acid,	.121
Sulphuric acid,	.463
Potash,	.749
Soda,	.482
Sand and insoluble silicats,	84.990
	100.014

This marl contains valuable proportions of potash, sulphuric acid, magnesia, lime and soda, and but a moderate quantity of phosphoric acid. It would be a useful application to exhausted land, especially with the addition of bone dust, or other phosphatic manures.

No. 727——LIMONITE. *Labeled "Iron ore in the preceding clay, &c., &c. Nelson county, Kentucky."*

Layers of dull yellowish-brown iron ore; adheres to the tongue.

Composition, dried at 212° F.—

Oxide of iron,	39.340	= 27.55 per cent. of *Iron*.
Alumina,	2.560	
Carbonate of lime,	.886	
Carbonate of magnesia,	4.827	
Brown oxide of manganese,	1.180	
Phosphoric acid,	.315	
Sulphuric acid,	.201	

Potash,	.668
Soda,	.342
Silex and insoluble silicates,	44.720
Water and loss,	4.961
	100.000

No. 728—MARL. *Labeled "Ash-colored shale, (Marl?) Big Lick, near Bell's and New Haven, Nelson county, Kentucky. Sub-carboniferous formation."*

Composition dried at 212° F.—

Alumina, and oxides of iron and manganese,	9.430
Carbonate of lime,	.843
Magnesia,	1.533
Phosphoric acid,	.114
Sulphuric acid,	.227
Potash,	.657
Soda,	.229
Sand and insoluble silicates,	85.840
Water and loss,	1.127
	100.000

As this contains a considerable proportion of potash and lime and magnesia it may be entitled to the denomination of marl. Like the preceding, its quantity of phosphoric acid is small.

No. 729—SOIL. *Labeled "Shell-earth, underlying the blue ash land at R. B. Grigsby's, three miles from Bloomfield; Nelson county, Kentucky. Lower Silurian formation."*

A dirty-buff colored earth, containing silicified fragments of shells, and some fragments of chert and ferruginous sandstone.

Composition, dried at 212° F.—

Organic and volatile matters,	4.200
Alumina,	5.190
Oxide of iron,	4.650
Carbonate of lime,	.396
Magnesia,	.613
Brown oxide of manganese,	.230
Phosphoric acid,	.172

Sulphuric acid,	.085
Potash,	.282
Soda,	.095
Sand and insoluble silicates,	84.495
	100.408

NICHOLAS COUNTY.

No. 730—SANDSTONE. *Labeled "Rock from the Blue Lick battle ground, Nicholas county, Kentucky. Lower Silurian."*

A fine-grained sandstone, containing a few specks of mica. Color dirty-buff; with thin bands of brownish and dirty-orange color. Adheres to the tongue.

Composition, dried at 212° F.—

Alumina, and oxides of iron and manganese,	4.140
Carbonate of lime,	.113
Magnesia,	.199
Phosphoric acid,	.092
Sulphuric acid,	.076
Potash,	.202
Soda,	.121
Sand and insoluble silicates,	93.390
Water and loss,	1.667
	100.000

The presence of this sandstone as a sub-stratum at the Blue Lick Springs is the reason of that sterility and paucity of soil, which has generally been attributed, by early observers, to the trampling of the herds of buffaloes, which formerly frequented the licks.

No. 731—SANDSTONE. *Labeled "Mudstone, from a pasture near Carlisle; (where cattle die of milk sickness;) Nicholas county, Kentucky."*

A friable argillaceous sandstone, of a dirty-buff color and imperfectly laminated structure. Exterior of the laminæ of a dark iron-rust-brown color, and covered with impressions of shells, entrochites, &c.

Composition, dried at 212° F.—

Alumina,	3.880
Oxide of iron,	4.680
Carbonate of lime,	.743
Magnesia,	.322
Brown oxide of manganese,	.290
Phosphoric acid,	.572
Sulphuric acid,	.100
Potash,	.473
Soda,	.233
Sand and insoluble silicates,	88.440
Loss,	.267
	100.000

Nothing in the composition of this rock explains the origin of milk sickness in this region.

No. 732—LIMESTONE. *Labeled "Modesta limestone. Cut of the Railroad, near Carlisle, Nicholas county, Kentucky."*

An olive-grey, impure limestone, full of fossil shells—weathered surface of a dirty-buff color.

Composition, dried at 212° F.—

Carbonate of lime,	78.680	= 44.150 per cent. of *Lime*.
Carbonate of magnesia,	1.566	
Alumina, oxides of iron and manganese,	2.480	
Phosphoric acid,	.247	
Sulphuric acid,	.270	
Potash,	.173	
Soda,	.172	
Silex and insoluble silicates,	16.640	
	100.228	

A good limestone for agricultural purposes, containing considerable proportions of phosphoric and sulphuric acids and alkalies. By its gradual disintegration it tends to renovate the soil which may rest upon it.

No. 733—MINERAL WATER. *Water of the Lower Blue Lick Spring. Nicholas county, Kentucky.*

The water of this celebrated spring has not been analyzed at this laboratory during the progress of this survey. But some years ago,

the writer submitted it to a full quantitative examination, and published the results as follows:

Although this celebrated water has, at various times, been *qualitatively tested*, and the nature of its principal larger ingredients ascertained, yet it has never been fully analyzed *quantitatively*, and the presence and proportions of its minuter constituents made out. To ascertain the exact weights and proportions of these several ingredients, and to detect and estimate the more minute, yet not less valuable medicinal agents of this water, was the object of the new investigation.

Nor is this object devoid of interest to the physician or the man of science. Chemical analyses frequently owe all their value to the minute ingredients which are detected. For example; the analysis of a soil is of very minor importance when it does not develope the proportions of the potash or phosphate of lime, and mineral waters frequently present medicinal virtues, in their use, which cannot be accounted for in the properties of the ingredients which are shown by a rough and imperfect analysis. Thus, the salt-sulphur water of Leamington, England, possesses virtues in the cure of scrofula, &c., which were unaccountable to physicians, until by the minute analysis of Prof. Daubeny, iodine and bromine were detected in it in small quantities.

The water of the Lower Blue Lick Springs, has an extensive reputation in Kentucky, and in the South generally; this being one of the oldest and best known watering places in the valley of the Ohio and Mississippi. Hundreds of invalids, as well as of seekers for recreation and pleasure, visit this pleasant locality every season, and thousands of barrels and of bottles of the water are annually put up for distant places in this and other States.*

This remarkable spring, it is well known, attracted the attention of the earliest settlers of Kentucky, by its strong odor of sulphuretted hydrogen, and the saltness of its waters. It was, indeed, from this source, that Boone and other pioneers obtained the salt with which to flavor their venison. Here, while engaged in procuring this necessary condiment, was he surprised and captured by the Indians; and here was fought one of the most disastrous, to the whites, of the early battles with the savages. The historian of Kentucky will always connect the name of this place with some of the most interesting events of its early annals. * * *

At the Blue Licks, beside the main spring, there are a number of minor ones, on the two sides of the Licking river and in its bed, the water of some of which has been examined by the author, and found to be very much like that of the principal spring in composition. Johnson's well, in Scott county, Ky., also presents a composition some-

* Put up in tight vessels it bears transportation very well; but as it is speedily altered after exposure to the air, it should be bottled, and corked and sealed very perfectly, for distant use.

what analogous to that of the Blue Lick water, but it is much weaker, and contains more magnesian salts.

While the water of the superficial wells and springs, on the blue limestone formation, are generally what is denominated *hard*, or *limestone water*—containing bi-carbonates of lime and magnesia, with a little iron, and some phosphate of lime, held in solution by carbonic acid; these salt wells, or "licks," so called, contain chlorides of sodium and potassium, chlorides of calcium and magnesium, sulphate and carbonate of lime, &c., and are frequently impregnated, to a greater or less degree, with sulphuretted hydrogen. Saline water of this character, as above intimated, has been frequently obtained on the blue limestone formation, by boring. For example, in the little town of Keene, in Jessamine county, Kentucky, a water was obtained in this manner, in 1848, by Mr. Wm. R. Dean, which is a very good salt sulphur water, and has been considerably employed for its medicinal properties. It contains sulphuretted hydrogen and carbonic acid gases; bi-carbonates of lime and magnesia, with a trace of bi-carbonate of soda; chlorides of sodium, calcium, magnesium, and doubtless of potassium, with a trace of iron; but this is much weaker than the Blue Lick water, containing only 1.6 grains of saline in the 1000 grains of the water; being only about one sixth the strength of the former. In a later testing, in May, 1850, it was found to be yet weaker, probably because of the then extremely wet season. This water has not been fully analyzed to detect the presence of iodine and bromine.

In Scott county, of this State, in a well bored to the depth of 176 feet in this limestone, Mr. W. Roszell obtained a water which contains a notable proportion of chlorides of sodium, calcium, and magnesium, &c., &c, and smells strongly of sulphurretted hydrogen. The water of another bored well, 105 feet deep, obtained in 1848, by Maj. B. Roberts, in Harrison county, also on the blue limestone formation, has a very slight bituminous or sulphurous odor, but contains as much as sixteen parts in the thousand of saline matters, principally chloride of sodium, with chlorides of potassium, calcium and magnesium; sulphate of lime, bi-carbonates of lime, magnesia and iron, and a trace of iodine. This is rather stronger in salts than the Blue Lick water, and differs from it also in its deficiency in sulphuretted hydrogen, but in other respects they resemble each other very much in composition.

Another well, 81½ feet deep, was made by boring, in Scott county, near Georgetown, on the property of Mr. R. Ford, the water of which contains as much as 4. per cent. of saline matter, principally common salt, with sulphates of lime and potash, chlorides of calcium and magnesium, &c., &c. Some of the wells in Lexington yield a water smelling slightly of sulphuretted hydrogen, and while penning these remarks, a

bottle of water was brought to me from a boring in progress, forty-five feet deep, in this city, which is a weak sulphur water.*

Saline, and saline sulphur-waters, therefore are quite frequent, comparatively, in our Blue Limestone strata; but amongst all the springs of this nature, known at present on this formation, in Kentucky, none are as valuable, and as remarkable, in many respects, as those of the lower Blue Licks.

The principal spring, of this locality, from which the water submitted to analysis was taken, is situated near the banks of the Licking river, flowing out about twenty feet above low water in that stream. It rises in a hexagonal basin of stone, which has been built for it, which is six feet two inches in diameter from one side to the opposite parrallel one, and about five or six feet in depth. The quantity of water which flows out varies in different seasons. When the water for the present examination was obtained, June 6, 1850, it was low in the spring and not running. The water in this basin was lowered about one foot by pumping out seventy-six barrels† in the course of three hours; and in the winter time the stream which flows out from it would probably fill a pipe three inches in diameter.

The temperature of this spring was observed by Major Richard Owen, Professor in the Western Military Institute located at the Blue Licks; who was kind enough also to procure and pack up for me with great care, the water, sediment and gas, from the spring, in the various bottles which had been prepared for the purpose. In six observations, at different times on June 4th and 5th, the external air varying from 60° to 76° F., the temperature of the water stood very constantly at 62°. This is about seven degrees above the mean temperature of this region, which is about 55°; and it is probable that the temperature of the water in the basin had been somewhat raised by the external heat of the atmosphere. When flowing rapidly it may perhaps be found to approximate more nearly to the mean annual temperature.

The mass of water in the spring presents a light yellowish-green color; partly owing, perhaps, to the reflection from the yellowish-grey sediment; for when it is taken up in a clear vessel it appears perfectly colorless and beautifully transparent. On standing exposed to the air, however, it becomes of a yellowish-green color, very perceptible in a white pitcher, or even in a white glass bottle. This color deepens on

*Associated with the water thus obtained by boring, in our blue limestone, is sometimes found a large quantity of light carburetted hydrogen gas. One remarkable instance occurred in Franklin county, at the mills of the Messrs. Steadman, where, as I am informed, this gas, in large quantities is poured out from the boring; the stream lasting for some time and perhaps existing at the present moment. The origin of this gas in the coal formations, where it is more abundant, is doubtless from the vegetable matters which formed the coal, but in this formation it is more difficult to explain. Unless we suppose it to be derived, like the fluid bitumen sometimes discovered in this rock, from the decomposition of the marine, vegetable, and animal remains in the strata, no other probable cause can be given for its production.

†These barrels will not contain more than twenty-five gallons.

boiling the water, but boiling does not cause it to appear in the recent water. This color, to which the spring probably owes its name of *Blue* Licks, is due to the decomposition of some of the dissolved ingredidients. On exposure to the air, the hydrogen, of the sulphuretted hydrogen, becomes converted into water by combining with oxygen from the atmosphere, while the sulphur, with the trace of iron, &c., are deposited as a light yellowish-green precipitate; at the same time, in consequence of the escape of some of the free carbonic acid, carbonate of lime is thrown down, which mixes with the sulphur precipitate. The minute portion of iron which exists in the recent water, probably as carbonate of the protoxide, losing its carbonic acid and oxygen, becomes a sulphuret by taking some of the sulphur of the decomposed sulphuretted hydrogen, and gives the greenish tinge to the water and its sediment.

In the water which has been bottled or brought in barrels from the spring, this change of color and consequent deposition, occur a few hours after it has been brought in contact with the air by uncorking and withdrawing a portion out of the vessel. It changes in a marked manner in flavor owing to the decomposition of the sulphuretted hydrogen; and after a few days exposure loses all smell and taste of this gas; as might be expected from its decomposible nature. To preserve its virtues in exportation, therefore, it should be bottled like a sparkling wine and used as soon as it is opened. In this manner, if but little air be left in the neck of the bottle and the cork is very tight and secured by sealing wax, it may be preserved unchanged for a considerable time. In the spring and its channel this decomposition and escape of gas continually takes place, causing the formation of sediment. Less decomposition would probably take place in the spring were its basin smaller, so that the water would be more rapidly renewed and it would expose less surface to the air.

Some of the *sediment* collected from the bottom of the spring, was found by analysis to contain the following ingredients, viz:

Sand, in considerable proportion;
Carbonates of lime and magnesia;
Sulphur;
Oxide and sulphuret of iron;
Alumina;
A trace of oxide of manganese;
Apocrenic acid;
A trace of crenic acid.

All these ingredients, except the sand, which is probably brought out mechanically suspended, were doubtless dissolved in the recent water, and were deposited on its exposure to the air.

In addition to the gases, sulphuretted hydrogen and carbonic acid, which are thus gradually decomposed in the water, or which escape insensibly from its surface, streams of bubbles of gas are continually rising through the spring and breaking into the atmosphere. Some of this *gas*, carefully collected for me by Maj. Owen, in bottles prepared for the purpose, was submitted to analysis, and found to consist mainly of nitrogen, mixed with about 4.5 per cent. of carbonic acid gas, containing only a trace of sulphuretted hydrogen.

The analysis of the water was performed in the chemical laboratory of the Medical Department of Transylvania University, at Lexington, with the assistance of Mr. A. Schue, of the Western Military Institute, and required at least ten days constant labor. I will not give the detail of the various processes, as this would be uninteresting to the general reader. Let it suffice to say that the amount of free sulphuretted hydrogen and carbonic acid was ascertained by placing, by means of a proper pipette, a measured quantity of the recent water, at the spring, in bottles containing, severally, solution of arsenious acid in hydrocholoric acid, and an ammoniacal solution of chloride of calcium. The precipitates in these bottles were examined in the laboratory, and the proportion of these gases accurately ascertained.

The estimation of the saline ingredients was made in the most careful manner, in some of the water which had been brought from the spring in tight glass-stoppered bottles. The quantity used in each estimation was not less than one thousand grains, and was sometimes as much as twelve thousand grains.

To estimate the bromine and iodine, a demijohn which would hold about one hundred pounds, was sent to the springs to be filled; intending to evaporate this quantity for the purpose, but by some accident it did not come to hand in time, and to avoid delay the estimation of these minute ingredients was made by operating on the residue obtained by evaporating 5½ lbs, troy, of the water, all that was left, of two gallons, from the other experiments. The iodine was estimated as iodide of palladium, and the bromine, precipitated as bromide of silver was estimated by the *indirect* method, as described in the recent works on chemical analysis.

The proportions of the alkalies were also separately estimated. In consequence of the failure to obtain the carboy of water, the *separate* proportions of the alumina, phosphate of lime, and oxide or proto-carbonate of iron, were not made out; this, however, is a matter of minor importance.

The *composition* of the Blue Lick water, according to this analysis, is as follows: calculated both in 1000 grains of the water, and in the wine pint of 7,680 grains, viz:

Specific gravity, - - - - - - - - - - 1.007

	Gases in the 1000 *Grains:*		*In the wine pint.*	
	Grains.	*Cubic inch.*	*Grains.*	*Cubic inch.*
Sulphuretted hydrogen gas,	0.03947	0.1086	0.303129	0.834048
Free carbonic acid gas,	0.3547	0.7600	2.724096	5.836800

The former is in the proportion of about 1.36th the voulme of the water, and the latter about 1.5th the volume.

Saline Contents in the 1000 *Grains:*		*In the wine pint.*
	Grains.	*Grains.*
Carbonate of lime, - - - - - -	0.3850000	2.9568000
Carbonate of Magnesia, - - - - - -	0.0022065	.0169459
Alumina, phosphate of lime and oxide of iron, -	0.0058330	0.0447974
Choride of sodium, - - - - - -	8.3472930	64.1072102
Chloride of potassum, - - - - - -	0.0226690	0.1740979
Chloride of magnesium, - - - - - -	0.5272000	4.0488960
Bromide of magnesium, - - - - - -	0.0039394	0.0302546
Iodine of magnesium, - - - - - -	0.0007340	0.0056371
Sulphate of lime, - - - - - -	0.5533300	4.2495744
Sulphate of potash, - - - - - -	0.1519190	1.1166738
Silicic acid, - - - - - -	0.0179400	0.1377792
Loss, - - - - - - - -	0.2819861	2.2158335
	10.3000000	79.1040000

The water also contains traces of oxide of manganese, and apocrenic and crenic acids.*

As it respects the medicinal virtues of this water, it is not necessary for me to say much. Knowing the nature and proportions of the ingredients, any well educated physician will understand its medicinal virtues and applications. It is undoubtedly a highly valuable saline sulphur water, and consequently acts as a nervous stimulant, diaphoretic, diuretic and emmenagogue; proving purgative only to some persons. Such waters are described by authors to be useful in chronic disorders of the liver, dyspepsia, chronic cutaneous diseases, chronic rheumatism and gout, secondary syphilis, dismenorrhœa, &c., &c.; and this water would doubtless be valuable in some scrofulous affections, more especially from the iodine and bromine which it contains.

The discovery of these ingredients in this water is a matter of great interest in a medical point of view. Although they exist in it in very small proportions, yet experience has demonstrated that they are

*The quantity of saline and other matters brought out from the interior by this and other similar springs is immense, and sets at defiance all efforts to find out their source.

Taking the data above given as to the quantity of water which flows out at this spring, we find that it emits 678 gallons per hour, equal to 26,272 gallons in the day of twenty-four hours. Supposing the saline matters to constitute but one per cent. of the water, the amount brought out in one hour would be more than than 58 ℔s, avoirdupois. But say that 50 ℔s an hour is the proportion, and the quantity will amount to 438,000 ℔s per annum. The specific gravity of common salt being 2,257, this quantity in a solid lump would contain about 310 cubic feet, or be enough to form a cube of salt nearly 7 feet on a side! And yet the water flows on without any sensible diminution of its saltness. Whence is all this saline matter obtained.

in sufficient amount to be active when the use of the water is continued for a length of time, in the quantities usually drank at the springs.

The use of the water as a bath, is a valuable adjuvant to its internal use in many cases. Its application to the cure of disease should, however, always be made under the directions of a physician."

It is not necessary to add any thing to these remarks at present.

OLDHAM COUNTY.

No. 734—SOIL. *Labeled "Virgin soil, woodland pasture, Mr. A. Hawley's farm, adjoining the field from which the cultivated soil was collected. Primitive forest growth, beech, sugar-tree, walnut, poplar, hickory, and large burr oak. Favistella bed, junction of the Upper and Lower Silurian formations. Oldham county, Kentucky."*

Color of the dried soil dark buff-grey. Washed with water it left 83. per cent. of sand, &c., of which all but 1.30 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of very small rounded ferruginous particles, with a few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than two grains of light brownish-grey extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.677
Alumina, oxides of iron and manganese, and phosphates,	.113
Carbonate of lime,	.557
Magnesia,	.133
Sulphuric acid,	.253
Potash,	.091
Soda,	.014
Silica,	.164
Loss,	.098
	2.100

The air-dried soil lost 3.00 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.778
Alumina,	2.214
Oxide of iron,	2.240
Carbonate of lime,	.340
Magnesia,	.328
Brown oxide of manganese,	.172
Phosphoric acid,	.251
Sulphuric acid,	.067
Potash,	.125
Soda,	.027
Sand and insoluble silicates,	89.420
Loss,	.038
	100.000

No. 735—Soil. *Labeled "Soil twenty years in cultivation; Mr. A. Hawley's farm. Astrea favosites beds; junction of the Upper and Lower Silurian formations. Oldham county, Kentucky."*

Color of the dried soil lighter than that of the last. Washed with water it left 76.9 per cent. of fine sand, &c., of which all but 1.37 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted of very small particles of ferruginous mineral, with very few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *rather more than a grain and a half of umber-brown extract,* dried at 212° F., which has the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.340
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	.700
Magnesia,	.100
Sulphuric acid,	.062
Potash,	.069
Soda,	.016
Silica,	.197
	1.547

The air-dried soil lost 2.20 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.001
Alumina,	2.270
Oxide of iron,	2.020
Carbonate of lime,	.170
Magnesia,	.275
Brown oxide of manganese,	.145
Phosphoric acid,	.128
Sulphuric acid,	.076
Potash,	.111
Soda,	.039
Sand and insoluble silicates,	91.295
Loss,	.470
	100.000

No. 736—SUB-SOIL. *Labeled "Sub-soil from the field twenty years in cultivation. Mr. A. Hawley's farm, Oldham county, Kentucky."*

Color of the dried sub-soil, which was in cloddy lumps, is grey-buff. Washed with water it left 72.43 per cent. of fine sand, &c., of which all but 2.83 per cent. was fine enough to pass through the finest bolting-cloth. This portion consisted of rounded reddish ferruginous particles, with a few quartzose.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *nearly a grain and a half of light brownish-grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.420
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	.263
Magnesia,	.090
Sulphuric acid,	.053
Potash,	.085
Soda,	.002
Silica,	.261
	1.237

The air-dried sub-soil lost 2.575 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.643
Alumina,	3.355
Oxide of iron,	2.540
Carbonate of lime,	.125
Magnesia,	.365
Brown oxide of manganese,	.145
Phosphoric acid,	.112
Sulphuric acid,	.050
Potash,	.130
Soda, a trace.	
Sand and insoluble silicates,	89.820
Loss,	.715
	100.000

The *sub-soil* does not differ much in composition from the surface soil. The soil of the old field shows the usual evidences of deterioration by cultivation.

No. 737—SOIL. *Labeled "Ashey white soil, one mile north-east of Lagrange, in a hollow; derived from a mudstone, near the base of the Upper Silurian formation, under the magnesian limestone. Oldham county, Kentucky."*

The dried soil is of a light yellowish-grey color. The coarse seive removed from it some small cherty fragments. Washed with water, it left 75.10 per cent. of fine sand, &c., of which all but 2.77 per cent. passed through the finest bolting-cloth. This coarser portion consisted of hard rounded particles of a ferruginous mineral, with a few clear grains and crystals of quartz and particles of chert.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *a little more than three grains of light-buff extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.800
Alumina, oxides of iron and manganese, and phosphates,	.597
Carbonate of lime,	1.117
Magnesia,	.209
Sulphuric acid,	.039

Potash,	.061
Soda,	.045
Silica,	.226
Loss,	.006
	3.100

The air-dried soil lost 1.475 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.537
Alumina,	1.120
Oxide of iron,	2.265
Carbonate of lime,	.239
Magnesia,	.233
Brown oxide of manganese,	.072
Phosphoric acid,	.107
Sulphuric acid,	.079
Potash,	.075
Soda,	.056
Silica,	92.746
Loss,	.112
	100.000

Rather a poor soil.

OWEN COUNTY.

No. 738—SOIL. *Labeled "Virgin soil, from Green Threlkeld's farm, four miles from Owenton. Primitive forest growth, beech, oak, and poplar. Lower Silurian formation. Owen county, Kentucky."*

Dried soil of a dark greyish-buff color. Washed with water it left 76.5 per cent. of fine sand, &c., of which all but 3.73 per cent. passed through the bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with very few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly two grains of yellowish-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.450
Alumina, oxides of iron and manganese, and phosphates,	.237
Carbonate of lime,	.763
Magnesia,	.061
Sulphuric acid,	.022
Potash,	.082
Soda,	.021
Silica,	.168
Loss,	.046
	1.850

The air-dried soil lost 3.225 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.978
Alumina,	3.970
Oxide of iron,	3.290
Carbonate of lime,	.180
Magnesia,	.444
Brown oxide of manganese,	.335
Phosphoric acid,	.179
Sulphuric acid,	.054
Potash,	.256
Soda,	.024
Sand and insoluble silicates,	87.195
Loss,	.095
	100.000

No. 739—SOIL. *Labeled "Same soil, from an old field forty years in cultivation; never manured; now in grass; Green Threlkeld's farm, four miles from Owenton, &c. Owen county, Kentucky."*

The dried soil is in cloddy lumps of a dark grey-buff color; a little lighter than that of the virgin soil. Washed with water it left 76.00 per cent. of fine sand, &c., of which all but 3.40 per cent. passed through the fine bolting-cloth. This coarser portion consisted of small rounded ferruginous particles with a few quartzose grains.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *less than one grain of greyish-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.370
Alumina, oxides of iron and manganese, and phosphates,	.080
Carbonate of lime,	.347
Magnesia,	.026
Sulphuric acid,	.022
Potash,	.079
Soda,	.012
Silica,	.013
Loss,	·031
	0.980

The air-dried soil lost 3.25 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.256
Alumina,	3.995
Oxide of iron,	3.290
Carbonate of lime,	.145
Magnesia,	.388
Brown oxide of manganese,	.180
Phosphoric acid,	.163
Sulphuric acid,	.050
Potash,	.179
Soda,	.017
Sand and insoluble silicates,	88.170
Loss,	.167
	100.000

No. 740—SUB-SOIL. *Labeled "Sub-soil from the same old field; Green Threlkeld's farm, four miles from Owenton, &c., &c. Owen county, Kentucky."*

Color of the dried sub-soil rather more reddish than that of the two preceding soils. Washed with water it left 71.86 per cent. of fine sand, &c., of which all but 2.60 per cent. passed through the fine bolting-cloth. This coarser portion consisted of small rounded particles of ferruginous matter.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *about a grain and a half of greyish-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.317
Alumina, oxides of iron, and phosphates,	.063
Carbonate of lime,	.570
Magnesia,	.013
Brown oxide of manganese,	.080
Sulphuric acid,	.033
Potash,	.122
Soda,	.056
Silica,	.247
	1.501

The air-dried soil lost 3.05 per cent. of moisture at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	3.146
Alumina,	4.343
Oxide of iron,	3.515
Carbonate of lime,	.195
Magnesia,	.441
Brown oxide of manganese,	.265
Phosphoric acid,	.163
Sulphuric acid,	.044
Potash,	.262
Soda,	.006
Sand and insoluble silicates,	87.380
Loss,	.240
	100.000

The sub-soil is not richer than the original surface-soil. The soil of the old field shows the usual evidence of the gradual loss of its essential elements, by cultivation without the return of manures. The sub-soil is richer in potash and lime than the surface-soil.

No. 741—SANDSTONE. *Labeled "Argillaceous sandstone; near Benj. Hardin's; Owen county, Kentucky. Lower Silurian formation."*

A dirty-buff, dull-looking sandstone; adhering somewhat to the tongue.

Composition, dried at 212° F.—

Alumina,	1.280
Oxide of iron,	5.040
Carbonate of lime,	1.193
Magnesia,	1.600
Brown oxide of manganese,	.240
Phosphoric acid,	.860
Sulphuric acid,	.184
Potash,	.602
Soda,	.212
Silex and insoluble silicates,	88.090
Water and loss,	.699
	100.000

Contains large proportions of phosphoric acid, potash, and lime.

No. 742—LIMESTONE. *Labeled "Nucula (sp?) bed; headwaters of Cedar creek; near Harmony, Owen county, Kentucky." Lower Silurian formation."*

A dull, grey, granular limestone, full of fossil shells, which are of a lighter color than the body of the stone, which is also dotted with small ochreous spots.

Composition, dried at 212° F.—

Carbonate of lime,	92.920	= 52.139 per cent. of *Lime*.
Carbonate of magnesia,	.559	
Alumina, and oxides of iron and manganese,	3.580	
Phosphoric acid,	.349	
Sulphuric acid,	.338	
Potash,	.162	
Soda,	.160	
Silex and insoluble silicates,	1.720	
Loss,	.212	
	100.000	

Like most of the Lower Silurian limestones, this is rich in phosphoric acid, sulphuric acid, and the alkalies, &c., &c.

PENDLETON COUNTY.

No. 743—Soil. *Labeled "Virgin soil from Wm. Ellis' land, six and a half miles north of Falmouth. Primitive forest growth large white and red oak, sugar-tree, black walnut, hickory, some black locust, and wild cherry. Under-growth small oaks. Lower Silurian formation. Pendleton county, Kentucky."*

Dried soil of a dark grey-buff color. Washed with water it left 78.17 per cent. of fine sand, &c., of which all but 1.37 per cent. passed through the finest bolting-cloth. This coarser portion was composed of rounded ferruginous particles, with a few of clear and yellow quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly three and a half grains of chestnut-brown extract*, dried at 212° F., which had the following *composition:*

	Grains.
Organic and volatile matters,	1.370
Alumina, oxides of iron and manganese, and phosphates,	.430
Carbonate of lime,	1.080
Magnesia,	.083
Sulphuric acid,	.051
Potash,	.031
Soda,	.145
Silica,	.164
	3.354

The air-dried soil lost 2.45 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition* viz:

Organic and volatile matters,	4.766
Alumina,	2.290
Oxide of iron,	2.685
Carbonate of lime,	.296
Magnesia,	.157
Brown oxide of manganese,	.145
Phosphoric acid,	.227
Sulphuric acid,	.107

Potash,	.207
Soda,	.078
Sand and insoluble silicates,	88.010
Loss,	.032
	100.000

No. 744—SOIL. *Labeled "Soil from a field forty to fifty years in cultivation; Wm. Ellis' farm, six and a half miles north of Falmouth, &c., &c. Pendleton county, Kentucky."*

Dried soil of a grey-buff color, rather lighter than that of the last. Washed with water it gave up 82.30 per cent. of fine sand, of which all but 1.53 per cent. passed through the finest bolting-cloth. This coarser portion consisted of rounded ferruginous particles principally.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up a little *more than two and a half grains of dark-brown extract,* dried at 212° F.; which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.240
Alumina, oxides of iron and manganese, and phosphates,	.480
Carbonate of lime,	.430
Magnesia,	.059
Sulphuric acid,	.131
Potash,	.058
Soda,	.074
Silica,	.177
	2.649

The air-dried soil lost 2.675 per cent. of *moisture,* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.906
Alumina,	2.565
Oxide of iron,	2.510
Carbonate of lime,	.275
Magnesia,	.341
Brown oxide of manganese,	.145
Phosphoric acid,	.178
Sulphuric acid,	.055

Potash,	.140
Soda,	.037
Sand and insoluble silicates,	88.570
Loss,	.278
	100.000

No. 745—SUB-SOIL. *Labeled "Sub-soil from Wm. Ellis' old field, forty to fifty years in cultivation, &c., &c. Pendleton county, Kentucky."* (*See preceding analyses.*)

The air-dried sub-soil is of a greyish-buff color, more yellowish than that of the preceding soils. Washed with water it left 69.73 per cent. of fine sand, &c., of which all but 1.77 per cent. was fine enough to go through the finest bolting-cloth. This coarser portion is composed of small rounded ferruginous particles, with a very few of quartzose.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *a little more than two grains of grey-buff extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.017
Alumina, oxides of iron and manganese, and phosphates,	.430
Carbonate of lime,	.347
Magnesia,	.083
Sulphuric acid,	.033
Potash,	.055
Soda,	.054
Silica,	.164
	2.183

The air-dried soil, lost 2.45 per cent. of *moisture* at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.459
Alumina,	3.500
Oxide of iron,	3.200
Carbonate of lime,	.162
Magnesia,	.685
Brown oxide of manganese,	.146
Phosphoric acid,	.195
Sulphuric acid,	.069

Potash,	.188
Soda,	.068
Sand and insoluble silicates,	88.010
Loss,	.298
	100.000

The sub-soil is not richer than the soil of the surface.

ROWAN COUNTY.

No. 746—LIMONITE, (IMPURE.) *Labeled "Iron ore, from Mr. Smedley's land, on the dividing ridge between Triplett creek and the north fork of Licking. On the surface of the ground, four miles from the railroad line. Rowan county, Kentucky. (Brought by Mr. Crow.)*

A portion of a thin layer of a purple-brown color; dense and hard; and appearing under the lens, to be composed of rounded particles of silicious sand, united by a ferruginous cement.

Specific gravity,	2.868
Composition, dried at 212° F.—	
Oxide of iron,	26.68
Alumina,	.98
Magnesia,	.33
Brown oxide of manganese,	.26
Sulphur,	.05
Potash,	.57
Combined water,	2.80
Sand and insoluble silicates,	68.92
	100.59

Too poor to be smelted alone for iron. It may be useful to mix with very rich ores which are deficient in silicious matter.

No. 747—LIMONITE. *Labeled "Iron ore, from S. Smedley's land, on the north fork of Licking river, about six miles from the railroad line. Picked up on the top of a ridge. Rowan county, Kentucky. (Brought by Mr. Crow.")*

A dense, compact mineral, of a dark reddish-brown color, with irregular cavities, lined with ochreous ore, and containing adhering and embedded small, rounded pebbles of milky quartz.

Specific gravity,		3.261
Composition, dried at 212° F.—		
Oxide of iron,	56.14	= 39.31 per cent. of *Iron*.
Alumina,	.96	
Magnesia,	.18	
Brown oxide of manganese,	.38	
Potash,	.21	
Soda,	.11	
Combined water,	8.64	
Silex and insoluble silicates,	31.78	
Lime, phosphoric acid, &c. and loss,	1.60	
	100.00	

A silicious ore, sufficiently rich to be profitably smelted.

SCOTT COUNTY.

No. 748—SOIL. *Labeled "Virgin soil, from woodland-pasture; James F. Robinson's farm, three quarters of a mile from Georgetown, on Elkhorn creek. Primitive forest growth, sugar-tree, white oak, black walnut, wild cherry, and black locust. Lower Silurian formation. Scott county, Kentucky."*

Dried soil of an umber color. Washed with water it left 86.03 per cent. of fine sand, &c., of which all but 6.53 per cent. passed through the finest bolting-cloth. This is composed of small rounded ferruginous particles, mostly soluble in hydrochloric acid.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than six grains of orange-brown extract,* dried at 212° F., which had the following *composition:*

	Grains.
Organic and volatile matters,	1.540
Alumina, oxides of iron and manganese, and phosphates,	.494
Carbonate of lime,	3.663
Magnesia,	.101
Sulphuric acid,	.045
Potash,	.071
Soda,	.113
Silica,	.087
	6.114

The air-dried soil gave up 5.45 per cent. of *moisture* when dried at 400° F.; and had the following *composition:*

Organic and volatile matters,	9.042
Alumina,	5.015
Oxide of iron,	5.310
Carbonate of lime,	1.020
Magnesia,	.293
Brown oxide of manganese,	.565
Phosphoric acid,	.438
Sulphuric acid,	.141
Potash,	.214
Soda,	.106
Sand and insoluble silicates,	78.145
	100.289

No. 749—SOIL. *Labeled "Same soil, from an old adjoining field, forty-five years or more in cultivation; now in wheat; James F. Robinson's farm, near Georgetown, Scott county, Kentucky, &c., &c."*

Dried soil of a dirty-buff color, lighter colored than the preceding. Washed with water it left 76.13 per cent. of fine sand, &c., of which all but 5.87 per cent. passed through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up to it *about six and a half grains of brownish-yellow extract,* dried at 212 F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	1.470
Alumina, oxides of iron and manganese, and phosphates,	.253
Carbonate of lime,	4.497
Magnesia,	.076
Sulphuric acid,	.045
Potash,	.058
Soda,	.049
Silica,	.130
	6.578

The air-dried soil lost 3.40 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.197
Alumina,	5.425
Oxide of iron,	5.110
Carbonate of lime,	1.195
Magnesia,	.504
Brown oxide of manganese,	.502
Phosphoric acid,	.319
Sulphuric acid,	.179
Potash,	.197
Soda,	.125
Sand and insoluble silicates,	81.260
	100.013

No. 750—SUB-SOIL. *Labeled "Sub-soil from the old field forty-five years or more in cultivation; James F. Robinson's farm, near Georgetown, Scott county, Kentucky, etc., etc."*

The dried sub-soil is of a dirty-buff color; rather clearer in color than the preceding. The coarse seive removed from it a few cherty fragments. (also an old rusty shingle nail and a percussion cap.) Washed with water it left 75.17 per cent. of fine sand, &c., of which all but 5.70 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with very few of quartzose.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up to it *about three and a half grains of grey extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.650
Alumina, oxides of iron and manganese, and phosphates,	.230
Carbonate of lime,	2.383
Magnesia,	.139
Sulphuric acid,	.023
Potash,	.035
Soda,	.086
Silica,	.143
	3.599

The air-dried soil lost 3.415 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.669
Alumina,	6.740
Oxide of iron,	5.735
Carbonate of lime,	.595
Magnesia,	.581
Brown oxide of manganese,	.397
Phosphoric acid,	.323
Sulphuric acid,	.136
Potash,	.183
Soda,	.031
Sand and insoluble silicates,	81.880
	101.270

The comparison, with each other, of the composition of these several fertile soils of the blue limestone formation, is highly interesting. It can be made in detail by any one who is interested in the subject. It will be seen in particular that a marked change has been produced, in the soil of the old field, by forty-five years of cultivation, most probably without manuring as is the general practice in Kentucky. The sub-soil is not as rich as the original virgin soil of the surface.

SHELBY COUNTY.

No. 751—MARL. *Labeled "Marl, associated with the Chætetes bed of of the blue limestone of the Lower Silurian formation. Shelby county, Kentucky."*

Friable lumps of a dirty-buff color. A little gritty under the teeth. Did not effervesce with hydrochloric acid.

Dried at 212° F., the air-dried marl lost 3.70 per cent. of *moisture.*

Composition dried at 212° F.—

Alumina, and oxides of iron and manganese,	13.130
Carbonate of lime,	1.290
Carbonate of magnesia,	.914
Phosphoric acid,	.284
Sulphuric acid,	.066
Potash,	.395
Soda,	.038
Sand and insoluble silicates,	80.690
Water, organic matter, and loss,	3.193
	100.000

Not very rich in phosphoric and sulphuric acids and the alkalies, and containing only a moderate quantity of carbonate of lime. It is not much better than many specimens of the soil from this formation.

No. 752—SOIL. *Labeled "Virgin upland soil, from Addison Jessee's farm. Overlies the Chaetetes and Leptaena beds of the blue limestone of the Lower Silurian formation. Primitive forest growth, principally beach, with some elm, oak, poplar, sugar-tree, and locust. Shelby county, Kentucky."*

Dried soil of a grey-brown color. Washed with water it left 75.30 per cent. of fine sand, &c., of which all but 4.37 per cent. passed through the fine bolting-cloth. This coarser portion consisted principally of rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than two grains of brownish extract*, dried at 212° F., which had the following *composition*:

	Grains.
Organic and volatile matters,	0.477
Alumina, oxides of iron and manganese, and phosphates,	.130
Carbonate of lime,	.714
Magnesia,	.166
Sulphuric acid,	.045
Potash,	.159
Soda,	.011
Silica,	.200
Loss,	.108
	2.010

The air-dried soil lost 3.565 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition*,:

Organic and volatile matters,	4.648
Alumina,	2 895
Oxide of iron,	3.280
Carbonate of lime,	.320
Magnesia,	.406
Brown oxide of manganese,	.170
Phosphoric acid,	.249
Sulphuric acid,	.064

49

Potash,	.159
Soda,	.026
Sand and insoluble silicates,	87.220
Loss,	.563
	100.000

No. 753—SOIL. *Labeled "Soil from a field which has been twenty-five years or more in cultivation; for ten years almost successively in corn; for the last six years in small grain, with clover and blue grass, in succession, to restore it. Addison Jessee's farm, &c., Shelby county, Kentucky."*

Color of the dried soil like that of the preceding. Washed with water it left 75.63 per cent. of fine sand, &c., of which all but 3.80 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *nearly two grains of brownish extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.486
Alumina, oxides of iron and manganese, and phosphates,	.213
Carbonate of lime,	.747
Magnesia,	.056
Sulphuric acid,	.048
Potash,	.085
Soda,	.045
Silica,	.171
	1.851

Dried at 400° F.; the air-dried soil lost 3.40 per cent. of *moisture*, and has the following *composition*:

Organic and volatile matters,	4.530
Alumina,	3.070
Oxide of iron,	3.190
Carbonate of lime,	.495
Magnesia,	.366
Brown oxide of manganese, a trace.	
Phosphoric acid,	.152
Sulphuric acid,	.050
Potash,	.128
Soda,	.051
Sand and insoluble silicates,	88.050
	100.055

No. 754—SUB-SOIL. *Labeled "Sub-soil from the same field, twenty-five years in cultivation, &c., &c. Addison Jessee's farm, Shelby county, Kentucky."*

Color of the dried sub-soil, like that of the preceding. Washed with water it left 73.80 per cent. of fine sand, &c., of which all but 0.63 per cent. was fine enough to pass through the fine bolting-cloth. This coarser portion consisted principally of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than one grain of light-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.280
Alumina, oxides of iron and manganese, and phosphates,	.120
Carbonate of lime,	.270
Magnesia,	.060
Sulphuric acid,	.120
Potash,	.070
Soda,	.020
Silica,	.177
	1.117

The air-dried soil lost 3.35 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.336
Alumina,	3.174
Oxide of iron,	4.080
Carbonate of lime,	.235
Magnesia,	.354
Brown oxide of manganese,	.045
Phosphoric acid,	.196
Sulphuric acid,	.059
Potash,	.214
Soda,	.014
Sand and insoluble silicates,	88.445
	100.152

The effects of cultivation on the soil are made manifest by the analyses. The sub-soil is richer in potash than the virgin soil above, and also richer in phosphoric acid than the soil of the cultivated field.

No. 755—SOIL. *Labeled "Virgin soil, from woods pasture, four and half miles from Shelbyville, on the Louisville turnpike; primitive forest growth, beech, white oak, and shell-bark hickory. Lower Silurian formation. Shelby county, Kentucky."*

The dried soil is of a dark brownish-buff color. Washed with water it left 81.27 per cent. of fine sand, &c., of which all but 3.90 per cent. passed through the finest bolting-cloth. This coarser portion consisted mainly of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water containing carbonic acid, gave up *more than three grains of light-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.650
Alumina, oxides of iron and manganese, and phosphates,	.322
Carbonate of lime,	1.813
Magnesia,	.072
Sulphuric acid,	.062
Potash,	.112
Soda,	.050
Silica,	.047
	3.128

The air-dried soil lost 3.575 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition*:

Organic and volatile matters,	4.734
Alumina,	4.590
Oxide of iron,	3.585
Carbonate of lime,	.445
Magnesia,	.533
Brown oxide of manganese,	.270
Phosphoric acid,	.479
Sulphuric acid,	.128
Potash,	.120
Soda,	.097
Sand and insoluble silicates,	85.670
	100.651

No. 756—Soil. *Labeled "Soil from an old turned-out field; four and a half miles from Shelbyville, on the Louisville turnpike, &c., &c. Shelby county, Kentucky."*

Color of the dried soil a very slight, but perceptible shade darker than of the preceding. Washed with water it left 77.50 per cent. of fine sand, of which all but 2.37 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *more than four grains of grey-brown extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.666
Alumina, oxides of iron and manganese, and phosphates,	.380
Carbonate of lime,	2.820
Magnesia,	.094
Sulphuric acid,	.062
Potash,	.133
Soda,	.070
Silica,	.074
	4.279

The air-dried soil lost 3.225 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.970
Alumina,	4.115
Oxide of iron,	3.660
Carbonate of lime,	.546
Magnesia,	.497
Brown oxide of manganese,	.515
Phosphoric acid,	.259
Sulphuric acid,	.067
Potash,	.173
Soda,	.093
Sand and insoluble silicates,	84.970
Loss,	.135
	100.000

No. 757—SUB-SOIL. *Labeled "Sub-soil from the same old turned-out field; four miles and a half from Shelbyville, on the Louisville turnpike, &c., &c. Shelby county, Kentucky."*

The air-dried soil is lighter and more yellowish colored than the preceding. Washed with water it left 77.93 per cent. of fine sand, &c., of which all but 2.40 per cent. was fine enough to pass through the finest bolting-cloth. This coarser portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *less than two grains of yellowish-grey extract*, dried at 212° F., which had the following composition:

Organic and volatile matters,	0.500
Alumina, oxides of iron and manganese, and phosphates,	.063
Carbonate of lime,	.753
Magnesia,	.027
Sulphuric acid,	.036
Potash,	.048
Soda,	.056
Silica,	.131
	1.614

The air-dried soil lost 2.925 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.245
Alumina,	4.690
Oxide of iron,	3.865
Carbonate of lime,	.246
Magnesia,	.558
Brown oxide of manganese,	.395
Phosphoric acid,	.393
Sulphuric acid,	.050
Potash,	.208
Soda,	.051
Sand and insoluble silicates,	86.320
	100.021

The soil of the old turned-out field, contains rather more organic matter than that from the woods-pasture, as is indicated also by its slightly darker color. The proportions of carbonate of lime, of oxide of manganese, and of potash, are also larger than those in the so-called

virgin soil. It gives up also a larger amount of soluble extract to the water which is charged with carbonic acid; but it will be seen that the excess is due to a larger proportion of carbonate of lime only. The soil of the old field has less of sand and insoluble silicates than the virgin soil. As it regards phosphoric and sulphuric acids, however, the latter soil contains the larger proportions. But it is probable, from these analyses, that the soil of the old field, after its season of fallow, would now be as fertile and productive as that of the woodland pasture, if brought again into cultivation—more especially, if some phosphatic manure, as bone dust, with a little Plaster of Paris, be used as a top dressing to it. Super-phosphate of lime would perhaps be still better. The sub-soil is about as rich as the surface soil, being richer in potash than that; to which circumstance, and the admixture of some of the sub-soil with that of the surface, in the course of the former cultivation of this field, may probably be attributed the fact, that its soil contains more of that alkali than the virgin soil from the woods pasture in the neighborhood.

SPENCER COUNTY.

No. 758—Soil. *Labeled "Virgin soil, from George Beam's farm; primitive growth, mostly beech, with some ash and poplar. Blue limestone, of the Lower Silurian formation. Spencer county, Kentucky."*

Color of the dried soil buff-grey. The coarse seive removed from it a few cherty fragments. Washed with water, it left 69.66 per cent. of fine sand, &c., of which all but 15.30 per cent. passed through the fine bolting-cloth. This coarser portion consisted principally of rounded particles of ferruginous mineral, with some rounded and angular grains of chert and milky quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than two grains and a half of yellowish-grey extract,* dried at 212° F., which had the following composition, viz:

Organic and volatile matters,	0.590
Alumina, oxide of iron, and phosphates,	.498
Carbonate of lime,	1.139
Magnesia,	.066
Brown oxide of manganese,	.258

Sulphuric acid,	.020
Potash,	.077
Soda,	.021
Silica,	.149
	2.798

The air-dried soil lost 3.35 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.317
Alumina,	3.096
Oxide of iron,	2.590
Carbonate of lime,	.345
Magnesia,	.493
Brown oxide of manganese,	.515
Phosphoric acid,	.187
Sulphuric acid,	.059
Potash,	.236
Soda,	.014
Sand and insoluble silicates,	87.970
Loss,	.178
	100.000

No. 759—Soil. *Labeled "Soil from an old field fifty to sixty years in cultivation; generally in corn, oats, and clover; never manured; Geo. Beam's farm; Spencer county, Kentucky."*

Dried soil of a dirty buff-grey color. The coarse seive removed from it some fragments of ferruginous sandstone. Washed with water it left 63.51 per cent. of fine sand, of which all but 16.90 per cent. passed through the fine bolting-cloth. Thir coarser portion consisted principally of small rounded ferruginous particles, with a few rounded and angular grains of chert and milky quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid *gave up more than two grains of brownish extract,* dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.440
Alumina, oxides of iron, and phosphates,	.348
Carbonate of lime,	.678
Magnesia,	.086
Brown oxide of manganese,	.059
Sulphuric acid,	.020
Potash,	.081
Soda,	.021
Silica,	.291
Loss,	.087
	2.111

The air-dried soil lost 2.425 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition*, viz:

Organic and volatile matters,	2.973
Alumina,	2.496
Oxide of iron,	2.640
Carbonate of lime,	.245
Magnesia,	.241
Brown oxide of manganese,	.170
Phosphoric acid,	.144
Sulphuric acid,	.041
Potash,	.183
Soda,	.047
Sand and insoluble silicates,	90.095
Loss,	.725
	100.000

No. 760—SUB-SOIL. *Labeled "Sub-soil from the same old field, fifty to sixty years in cultivation; Geo. Beam's farm, &c. Spencer county, Kentucky."*

Dried sub-soil of grey-buff color. Washed with water it left 65.50 per cent. of fine sand, of which all but 1.40 per cent. passed through the fine bolting-cloth. This coarser portion consisted of small rounded ferruginous particles, with a few rounded and angular ones of milky and reddish quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *rather more than a grain of light yellowish-grey extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.120
Alumina, oxides of iron and manganese, and phosphates,	.058
Carbonate of lime,	.558
Magnesia,	.033
Sulphuric acid,	.013
Potash,	.067
Soda,	.012
Silica,	.139
Loss,	·050
	1.050

The air-dried sub-soil gave up 3.075 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.347
Alumina,	2.665
Oxide of iron,	3.175
Carbonate of lime,	.220
Magnesia,	.454
Brown oxide of manganese,	.164
Phosphoric acid,	.106
Sulphuric acid,	.062
Potash,	.154
Soda,	.030
Sand and insoluble silicates,	90.320
Loss,	.313
	100.000

The change of composition, produced by the cultivation of the soil of the old field, is shown in a marked manner by the analyses, and is apparently the greater because the sub-soil is not naturally as rich as the surface-soil, and has doubtless been mixed more or less with it in the operations of ploughing, &c.

No. 761—MARL. *Labeled "Marl, interstratified with the blue limestone; near Taylorsville; Spencer county, Kentucky."*

Bluish-grey, soft friable, irregular porous lumps. Effervesces with acids; very little grittyness under the teeth.

Dried at 212° F., it lost 1.40 per cent. of *moisture*.

Composition, dried at 212° F.—

Alumina, and oxides of iron and manganese,	12.655
Carbonate of lime,	5.890
Carbonate of magnesia,	.979
Phosphoric acid,	.123
Sulphuric acid,	.485
Potash,	.424
Soda,	.148
Sand and insoluble silicates,	76.040
Water, organic matter, and loss,	3.256
	100.000

Like some of the blue limestone marls previously examined it contains considerable proportion of lime, potash, and sulphuric acid, but less of phosphoric acid than would be desirable in a marl. If not required to be carted to a great distance it might be advantageously used on exhausted land; especially with the addition of some phosphatic manure, as bone-dust, super-phosphate of lime or good guano.

TAYLOR COUNTY.

No. 762—SOIL. *Labeled "Virgin soil; the fine mealy soil of the Knobs, derived from the sub-carboniferous ash-colored clays and washings from the fine-grained sandstone of the Knobs, one mile from Allen Garrett's house, in the north-eastern part of Taylor county, Kentucky."*

Dried soil of a buff-grey color. Washed with water it left 87.10 per cent. of fine sand, &c., of which all but 5.03 per cent. passed through the fine bolting-cloth. This coarser portion consisted principally of rounded ferruginous particles, with small clear quartz crystals, and rounded grains of chert and reddish quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than five grains of nearly black extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	2.130
Alumina, oxides of iron and manganese, and phosphates,	1.321
Carbonate of lime,	1.047
Magnesia,	.209

Sulphuric acid,	.027
Potash,	.125
Soda,	.043
Silica,	.143
	5.115

The air-dried soil lost 2.85 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	7.075
Alumina,	3.765
Oxide of iron,	3.110
Carbonate of lime,	.172
Magnesia,	.435
Brown oxide of manganese,	.095
Phosphoric acid,	.146
Sulphuric acid,	.103
Potash,	.146
Soda,	.046
Sand and insoluble silicates,	85.345
	100.438

No. 763—SOIL. *Labeled "Virgin soil from the woods on the sub-carboniferous limestone formation. Primitive forest growth, large oaks, &c.; four miles north of Campbellsville, Taylor county, Kentucky."*

Dried soil of a dark buff-grey color. The coarse seive removed from it some ferruginous and quartzose fragments. Washed with water it left 78.63 per cent. of fine sand, &c., of which all but 9.50 per cent. passed through the fine bolting-cloth. This coarser portion consisted of small fragments of fossils and rounded ferruginous and quartzose particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than four and a half grains of dark-brown extract,* dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	2.370
Alumina, oxides of iron and manganese, and phosphates,	1.164
Carbonate of lime,	.713
Magnesia,	.157

Sulphuric acid,	.045
Potash,	.125
Soda,	.047
Silica,	.033
	4.654

The air-dried soil lost 2.425 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	5.816
Alumina,	2.530
Oxide of iron,	2.910
Carbonate of lime,	.122
Magnesia,	.423
Brown oxide of manganese,	.120
Phosphoric acid,	.105
Sulphuric acid,	.067
Potash,	.125
Soda,	.052
Sand and insoluble silicates,	87.330
Loss,	.400
	100.000

Of these two soils, the first is slightly more fertile than the other.

TRIMBLE COUNTY.

No. 764—SOIL. *Labeled "Virgin soil, Henry Tyris' farm, a quarter of a mile east of Bedford. Primitive forest growth, beech, poplar, white oak, hickory and blue ash. Over the magnesian, earthy and cherty beds of the Upper Silurian formation. Trimble county, Kentucky."*

The dried soil is of a light buff-grey color. It is in a state of very fine division. Contains a little charcoal. Washed with water it left 73. per cent. of fine sand, &c., of which all but 1.10 per cent. passed through the finest bolting-cloth. This coarser portion consisted of small rounded quartzose grains, with a very few of hyaline quartz.

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, left *more than three grains of brown extract,* dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.217
Alumina, oxides of iron and manganese, and phosphates,	.714
Carbonate of lime,	.963
Magnesia,	.099
Sulphuric acid,	.079
Potash,	.047
Soda,	.003
Silica,	.260
	3.382

The air-dried soil lost 2.50 per cent. of moisture at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.308
Alumina,	2.530
Oxide of iron,	1.990
Carbonate of lime,	.320
Magnesia,	.232
Brown oxide of manganese,	.170
Phosphoric acid,	.089
Sulphuric acid,	.033
Potash,	.213
Soda,	.047
Sand and insoluble silicates,	90.195
	100.127

No. 765—SOIL. *Labeled "Soil from an old field, Henry Tyris' farm; (same locality as the last;) forty to fifty years in cultivation; now lying waste, and has been for several years. Trimble county, Kentucky."*

Dried soil darker colored than the preceding; (grey-ochreous; like a sub-soil.) A few fragments of chert, quartz, and ferruginous mineral were removed from it by the coarse seive. Washed with water it left 80.07 per cent. of *fine sand,* &c., of which all but 2.87 per cent. passed through the finest bolting-cloth. This coarser portion consisted of dull rounded particles of ferruginous mineral, with very few of clear and yellow quartz.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly two and a half grains*

of buff extract, dried at 212° F., which had the following *composition,* viz:

	Grains.
Organic and volatile matters,	0.670
Alumina, oxides of iron and manganese, and phosphates,	.331
Carbonate of lime,	.873
Magnesia,	.143
Sulphuric acid,	.119
Potash,	.059
Soda,	.040
Silica,	.200
Loss,	.064
	2.499

The air-dried soil lost 2.45 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.434
Alumina,	2.995
Oxide of iron,	2.890
Carbonate of lime,	.220
Magnesia,	.291
Brown oxide of manganese,	.170
Phosphoric acid,	.096
Sulphuric acid,	.020
Potash,	.152
Soda,	.049
Sand and insoluble silicates,	89.920
	100.237

No. 766—Sub-soil. *Labeled "Sub-soil from the same old field, forty to fifty years in cultivation, &c., &c. Trimble county, Kentucky."*

Dried soil lighter colored than the preceding, (slightly lighter than No. 764, and not so yellowish as No. 765, which looks more like a sub-soil than this does.) The coarse seive removed from it some small angular fragments of ferruginous sandstone. Washed with water it left 75.53 per cent. of fine sand, &c., of which all but 2.83 per cent. was fine enough to go through the finest bolting-cloth. This portion consisted mainly of dull, rounded ferruginous particles, with a few of hyaline quartz.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *more than three grains of light-buff extract*, dried at 212° F., which had the following *composition*, viz:

Organic and volatile matters,	0.660
Alumina, oxides of iron and manganese, and phosphates,	.403
Carbonate of lime,	1.530
Magnesia,	.090
Sulphuric acid,	.071
Potash,	.041
Soda,	.027
Silica,	.207
	3.029

The air-dried sub-soil gave up 2.425 per cent. of *moisture* at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.136
Alumina,	3.470
Oxide of iron,	2.640
Carbonate of lime,	.170
Magnesia,	.294
Brown oxide of manganese,	.245
Phosphoric acid,	.079
Sulphuric acid,	.015
Potash,	.181
Soda,	.028
Sand and insoluble silicates,	90.160
	100.418

UNION COUNTY.

No. 767—SOIL. *Labeled "Soil from Casey's creek, on the east side of the road; Murray's farm. Coal Measures. Union county, Kentucky."*

Dried soil mouse-colored. Washed with water it left 82.97 per cent. of fine sand, &c., of which all but 1.80 per cent. passed through the finest bolting-cloth. This coarser portion is principally small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly two grains of yellowish-grey extract*, dried at 112° F., which had the following composition:

	Grains.
Organic and volatile matters,	0.617
Alumina, oxides of iron and manganese, and phosphates,	.200
Carbonate of lime,	.730
Magnesia,	.123
Sulphuric acid,	.053
Potash,	.033
Soda,	.055
Silica,	.117
	1.928

The air-dried soil lost 3.50 per cent. of *moisture*, at 400° F.; dried at which temperature it has the following *composition* viz:

Organic and volatile matters,	3.720
Alumina,	3.465
Oxide of iron,	2.920
Carbonate of lime,	.624
Magnesia,	.630
Brown oxide of manganese,	.950
Phosphoric acid,	.196
Sulphuric acid,	.067
Potash,	.133
Soda,	.104
Sand and insoluble silicates,	87.510
	100.319

No. 768—SUB-SOIL. *Labeled "Sub-soil or clay, near the salt wells, on the Bald Hill fault; Holland Lick. Coal Measures. Union county, Kentucky."*

Dried sub-soil of a dark buff-grey color.

Dried at 212° F., it lost 1.30 per cent. of *moisture* and had the following *composition:*

Organic and volatile matters,	2.309
Alumina, oxides of iron and manganese, and phosphates,	3.910
Carbonate of lime,	.590
Magnesia,	.466
Sulphuric acid,	.124
Chlorine,	.080

Potash,	.188
Soda,	.213
Sand and insoluble silicates,	92.120
	100.000

No. 769—Soil. *Labeled "Soil from remarkable flat, post-oak glades. Coal Measures. Union county, Kentucky."*

Soil of a light grey-buff color. In cloddy lumps. Sifted out, with the coarse seive, some rounded ferruginous concretions of the size of a large white mustard seed and a small pebble of milky quartz. Washed with water it left 62.20 per cent. of fine sand, &c., of which all but 11.47 per cent. passed through the fine bolting-cloth. This coarser portion consisted of rounded ferruginous particles, with some of hyaline, milky, and red quartz.

One thousand grains of the air-dried soil, digested for twenty days in water charged with carbonic acid, gave up *less than a grain of yellowish-grey extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.333
Alumina, oxides of iron and manganese, and phosphates,	.190
Carbonate of lime,	.039
Magnesia,	.064
Sulphuric acid,	.016
Potash,	.037
Soda,	.056
Silica,	.131
	0.866

The air-dried soil, lost 3.50 per cent. of *moisture* at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.333
Alumina,	4.290
Oxide of iron,	5.365
Carbonate of lime, a trace.	
Magnesia,	.541
Brown oxide of manganese,	.495
Phosphoric acid,	.162
Sulphuric acid,	.076

Potash,	.231
Soda,	.111
Sand and insoluble silicates,	85.330
Loss,	.066
	100.000

The soil, being remarkably deficient in lime, would no doubt be much benefited by its application, or that of calcareous marl.

WASHINGTON COUNTY.

No. 770—SOIL. *Labeled "Virgin soil, from woods, on the Spirifer, Orthis and Leptæna beds of the blue limestone of the Lower Silurian formation. Stephen C. Brown's farm, Pleasant Grove settlement. Primitive forest growth, large yellow poplar and beech. Washington county, Kentucky."*

Dried soil of a yellowish, light-umber color. Washed with water it left 85.83 per cent. of fine sand, &c., of which all but 3.97 per cent. passed through the fine bolting-cloth. This coarser portion consisted of rounded ferruginous particles

One thousand grains of the air-dried soil, digested for a month in water containing carbonic acid, gave up *more than six and a half grains of brown extract*, dried at 212° F., which had the following *composition:*

Organic and volatile matters,	1.550
Alumina, oxides of iron and manganese, and phosphates,	1.310
Carbonate of lime,	3.347
Magnesia,	.143
Sulphuric acid,	.033
Potash,	.203
Soda,	.033
Silica,	.131
	6.750

The air-dried soil lost 5.05 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	7.753
Alumina,	3.790
Oxide of iron,	3.930
Carbonate of lime,	.636
Magnesia,	.333
Brown oxide of manganese,	.495

Phosphoric acid,	.488
Sulphuric acid,	.084
Potash,	.231
Soda,	.030
Sand and insoluble silicates,	82.190
Loss,	.040
	100.000

No. 771—Soil. *Labeled "Same soil, from a field fifty years or more in cultivation, (a field cleared by Gen. Walton); Stephen C. Brown's farm. Pleasant Grove settlement, Washington county, Kentucky, &c."*

Color of the dried soil somewhat lighter, and more buff, than that of the preceding. The coarse seive removed from it a few fragments of ferruginous sandstone. Washed with water it left 79.23 per cent. of sand &c., of which all but 7.43 per cent. passed through the finest bolting-cloth. This portion consisted of small rounded ferruginous particles.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *more than three and a half grains of grey-buff extract*, dried at 212° F.; which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	0.853
Alumina, oxides of iron and manganese, and phosphates,	.253
Carbonate of lime,	2.170
Magnesia,	.090
Sulphuric acid,	.027
Potash,	.173
Soda,	.023
Silica,	.123
	3.712

The air-dried soil lost 3.555 per cent. of *moisture*, at 400° F.; dried at which temperature it had the following *composition:*

Organic and volatile matters,	5.635
Alumina,	4.515
Oxide of iron,	4.145
Carbonate of lime,	.396
Magnesia,	.233
Brown oxide of manganese,	.420

Phosphoric acid,	.445
Sulphuric acid,	.067
Potash,	.191
Soda,	.011
Sand and insoluble silicates,	83.940
Loss,	.002
	100.000

No. 772—SUB-SOIL. *Labeled "Sub-soil from the same old field, fifty years or more in cultivation. Stephen C. Brown's farm, Pleasant Grove settlement, Washington county, Kentucky, &c."*

Color of the dried sub-soil still more buff and lighter than the last. Washed with water it left 73.93 per cent. of fine sand, &c., of which all but 6.37 per cent. passed through the finest bolting-cloth. This coarser portion cousisted of small rounded ferruginous particles.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave to it *nearly two grains of light greyish-brown extract*, dried at 212° F., which had the following *composition:*

	Grains.
Organic and volatile matters,	0.383
Alumina, oxides of iron and manganese, and phosphates,	.080
Carbonate of lime,	1.130
Magnesia,	.037
Sulphuric acid,	.022
Potash,	.035
Soda,	.065
Silica,	.113
	1.865

The air-dried sub-soil lost 3.45 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.340
Alumina,	4.565
Oxide of iron,	4.385
Carbonate of lime,	.222
Magnesia,	.308
Brown oxide of manganese,	.345
Phosphoric acid,	.346

Sulphuric acid,	.042
Potash,	.160
Soda,	.038
Sand and insoluble silicates,	86.175
Loss,	.074
	100.000

The influence of the fifty years cultivation of the old field, is evidently shown in the above analyses, every ingredient of the soil having been diminished, except the alumina and oxide of iron, sand and insoluble silicates. The sub-soil is not as rich as the surface soil.

No. 773—SOIL. *Labeled "Virgin soil; Wm. Lynton's woods pasture, south-west side of Beech fork of Salt river. Lower Silurian formation. Washington county, Kentucky."*

Dried soil of a greyish-buff color. Washed with water it left 77.47 per cent. of fine sand, &c., of which all but 3.40 per cent. passed through the finest bolting-cloth. This coarser portion consists of small rounded ferruginous concretions, with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *nearly four grains of reddish-brown extract*, dried at 212 F., which has the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.170
Alumina, oxides of iron and manganese, and phosphates,	.650
Carbonate of lime,	1.617
Magnesia,	.094
Sulphuric acid,	.045
Potash,	.218
Soda,	.040
Silica,	.148
	3.982

The air-dried soil lost 3.30 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	4.576
Alumina,	3.440
Oxide of iron,	2.990
Carbonate of lime,	.322
Magnesia,	.388
Brown oxide of manganese,	.170
Phosphoric acid,	.196

Sulphuric acid,	.067
Potash,	.154
Soda,	.021
Sand and insoluble silicates,	87.410
Loss,	.266
	100.000

No. 774—Soil. *Labeled "Same soil, from an old field, fifty years in cultivation; Wm. Lynton's farm; south-west side of Beech fork of Salt river. Washington county, Kentucky, &c."*

Dried soil of a greyish-buff color lighter than that of the preceding. Washed out of it 69.07 per cent. of fine sand, &c., of which all but 5.43 per cent. passed through the finest bolting-cloth. This coarse portion consisted of small rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried soil, digested for a month in water charged with carbonic acid, gave up *less than three and a half grains of brownish extract*, dried at 212° F., which had the following *composition*, viz:

	Grains.
Organic and volatile matters,	1.070
Alumina, oxides of iron and manganese, and phosphates,	.497
Carbonate of lime,	.387
Magnesia,	.100
Sulphuric acid,	.055
Potash,	.034
Soda,	.032
Silica,	.131
	2.306

The air-dried soil lost 2.15 per cent. of *moisture*, at 400° F., dried at which temperature it has the following *composition:*

Organic and volatile matters,	3.055
Alumina,	3.015
Oxide of iron,	3.390
Carbonate of lime,	.222
Magnesia,	.344
Brown oxide of manganese,	.175
Phosphoric acid,	.161
Sulphuric acid,	.059

Potash,	.132
Soda,	.035
Sand and insoluble silicates,	89.070
Loss,	.342
	100.000

No. 775—SUB-SOIL. *Labeled "Sub-soil of the same old field, fifty years in cultivation; Wm. Lynton's farm, &c., &c. Washington county, Kentucky."*

Dried sub-soil of a greyish-buff color, lighter than that of the two preceding. Washed out of it 66.70 per cent. of *fine sand, &c.,* of which all but 3.97 per cent. passed through the finest bolting-cloth. This coarser portion consisted principally of rounded ferruginous particles, with a few of chert.

One thousand grains of the air-dried sub-soil, digested for a month in water charged with carbonic acid, gave up *a little more than a grain and a half of grey-buff extract,* dried at 212° F., which had the following composition, viz:

	Grains.
Organic and volatile matters,	0.630
Alumina, oxides of iron and manganese, and phosphates,	.450
Carbonate of lime,	.187
Magnesia,	.066
Sulphuric acid,	.045
Potash,	.037
Soda,	.038
Silica,	.187
	1.640

The air-dried sub-soil lost 2.89 per cent. of *moisture* at 400° F.; dried at which temperature it has the following *composition:*

Organic and volatile matters,	2.894
Alumina,	3.565
Oxide of iron,	3.440
Carbonate of lime,	.145
Magnesia,	.443
Brown oxide of manganese,	.170
Phosphoric acid,	.129

Sulphuric acid,	.077
Potash,	.128
Soda,	.052
Sand and insoluble silicates,	89.020
	100.000

The remarks appended to the preceding set of soils apply pretty fully to these also.

WOODFORD COUNTY.

No. 776—LIMESTONE. *Labeled "Lowest rock in the bluff at Shryock's ferry; Kentucky river; Versailles road; Woodford county, Kentucky. Lower Silurian formation."*

A greyish drab-colored, fine granular limestone; homogeneous in structure; with no appearance of fossils in the specimen analyzed. Under the lens appearing to be made up of pretty pure, fine, crystalline grains. Powder yellowish-white.

Specific gravity, - - - - - - - - - 2.655

Dried at 212° F., the powdered rock lost 0.40 per cent. of *moisture.*

Composition, dried at 212° F.—

Carbonate of lime,	59.86	= 33.59 per cent. of *Lime.*
Carbonate of magnesia,	36.64	= 17.44 per cent. of *Magnesia.*
Alumina, oxides of iron and manganese, and phosphates,	.98	
Sulphuric acid,	.16	
Potash,	.40	
Soda,	.08	
Silex and insoluble silicates,	2.48	
	100.60	

A pretty pure magnesian limestone, which promises to be a durable building material; resembles, in composition, the building stone from Grimes' and the neighboring quarries in Fayette county, on the Kentucky river.

TABLE 1.

Soils, Sub-soils, and Marls.

Number in the report.	County.	Dissolved from 1000 grains by water containing carb. acid.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia and carbonate.	Oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Formation, &c.
557	Anderson,	2.201	4.125	5.463	1.615	6.305	0.345	0.335	0.315	0.181	0.056	0.156	0.023	84.845	Lower Silurian.
558	Anderson,	2.105	3.075	4.332	2.165	2.890	.215	.465	.220	.103	.032	.101	.047	89.140	Lower Silurian.
559	Anderson,	0.789	3.250	3.213	2.465	3.555	.070	.601	.220	.142	.056	.130	.026	80.970	Lower Silurian, sub-soil.
565	Boone,	4.600	4.635	7.827	2.495	2.790	.395	.495	.195	.318	.084	.175	.040	84.620	Lower Silurian.
566	Boone,	3.100	3.750	5.506	3.520	3.124	.495	.469	.245	.126	.187	.152	.032	85.595	Lower Silurian.
567	Boone,	1.936	3.190	3.455	3.945	3.420	.265	.536	.295	.476	.067	.213	.050	87.645	Lower Silurian, sub-soil.
568	Bourbon,	6.078	5.120	8.406	5.745	5.185	.945	.170	.370	.335	.119	.227	.133	79.045	Lower Silurian.
569	Bourbon,	3.149	3.840	5.574	4.925	4.185	.485	.110	.395	.330	.085	.209	.114	83.310	Lower Silurian.
570	Bourbon,	2.263	3.840	4.196	5.360	4.313	.355	.521	.420	.440	.085	.195	.100	84.070	Lower Silurian, sub soil.
571	Bourbon,	1.834	6.450	4.783	12.785	9.420	6.235	1.946	.495	.425	.050	.840	.116	63.770	Lower Silurian, shell earth and under clay.
574	Bourbon,	6.760	5.865	7.702	4.620	6.585	.622	.508	.720	.321	.145	.224	.077	78.680	Lower Silurian.
575	Bourbon,	2.834	4.500	5.837	5.195	5.910	.446	.416	.593	.282	.101	.248	.103	81.080	Lower Silurian.
576	Bourbon,	2.671	4.600	4.785	5.275	5.660	.421	.517	.345	.243	.110	.217	.130	82.230	Lower Silurian, sub-soil.
577	Bourbon,	1.849	7.085	4.875	8.720	10.015	.446	.753	.470	.221	.093	.347	.159	74.145	Lower Silurian un'r-clay.
580	Boyle,	5.683	3.500	5.958	3.515	3.835	.247	.571	.320	.486	.119	.183	.071	83.770	Lower Silurian.
581	Breckinridge,	1.827	2.625	3.532	2.080	2.215	.022	.323	.220	.108	.059	.194	.017	91.145	Sub-carboniferous.
582	Breckinridge,	1.900	2.680	5.030	1.640	1.490	.147	.285	.095	.139	.042	.198	.020	90.420	Sub carboniferous.
583	Bullitt,	2.022	4.680	5.665	2.476	4.790	.196	.526	.176	.253	.054	.258	.058	85.056	Devonian.
584	Bullitt,	1.390	2.920	3.120	2.390	2.740	.182	.348	.165	.097	.067	.145	.037	90.555	Upper Silurian.
585	Bullitt,	0.834	2.725	3.696	1.890	2.215	.072	.320	.145	.070	.055	.104	.058	91.695	Upper Silurian.
586	Bullitt,	1.321	3.250	3.229	4.345	4.495	.197	.289	.012	.109	.050	.235	.042	86.720	Upper Silurian, sub soil.
587	Bullitt,	-	2.550	1.904	5.480		41.740	1.088	-	.157	.066	.573	.152	48.084	Upper Silurian, marl.
588	Bullitt,	-	3.150	6.214	5.230		11.190	2.147	-	trace.	.066	.308	.055	74.079	Upper Silurian, marl.
590	Campbell,	2.874	3.350	5.614	3.084	2.685	.274	.474	.110	.245	.101	.158	.108	86.730	Lower Silurian.
591	Campbell,	1.386	1.925	3.441	2.290	2.110	.146	.592	trace.	.177	.119	.111	.052	91.095	Lower Silurian.
592	Campbell,	0.864	2.700	2.826	3.740	3.270	.072	.430	.055	.146	.076	.159	.048	88.845	Lower Silurian, sub-soil.

593	Carroll,	4.890	3.800	5.744	3.910	3.455	.245	.527	.229	.396	.054	.312	.022	85.483	Lower Silurian.
594	Carroll,	4.342	2.375	3.618	2.820	2.845	.170	.340	.195	.203	.038	.287	.064	89.921	Lower Silurian.
595	Carroll,	1.919	2.300	2.814	2.470	2.630	.280	.300	.180	.227	.059	.256	.026	90.515	Lower Silurian, sub-soil.
596	Crittenden,	1.057	3.415	4.695	5.070	5.285	.050	.606	a trace.	.106	.167	.188	.067	83.548	Millstone grit.
597	Daviess,	4.433	4.900	6.972	1.360	1.660	.536	.358	.218	.177	.103	.193	.029	88.394	Coal Measures.
598	Daviess,	3.720	2.880	6.301	1.776	2.380	.416	.341	.038	.151	.095	.158	.027	89.236	Coal Measures.
599	Daviess,	1.587	2.400	2.868	1.756	2.520	.038	.156	.174	.177	.068	.097	.015	92.276	Coal Measures, sub-soil.
603	Franklin,	5.070	3.440	4.722	2.156	5.120	1.490	.832	.038	.304	.055	.212	.065	84.974	Lower Silurian.
604	Franklin,	5.860	3.920	5.911	2.550	4.380	1.470	.826	.375	.433	.095	.251	.007	83.936	Lower Silurian.
606	Franklin,	2.380	3.790	5.935	2.840	2.370	.295	.296	.220	.182	.084	.196	.040	87.280	Lower Silurian.
607	Franklin,	1.525	4.125	3.911	3.220	4.290	.305	.271	.320	.350	.050	.200	.017	87.280	Lower Silurian.
608	Franklin,	1.436	4.815	3.405	4.095	4.825	.246	.450	.335	.359	.081	.202	.029	85.810	Lower Silurian, sub soil.
611	Franklin,	1.000	4.400	4.205	6.390	7.240	.097	.781	.145	.182	.033	.444	.032	80.580	Lower Silurian, un. clay.
612	Franklin,	3.083	5.625	7.072	3.890	4.785	.495	.607	.272	.404	.153	.215	.084	82.270	Lower Silurian.
613	Franklin,	3.037	4.250	6.292	3.975	4.045	.430	.519	.196	.305	.093	.206	.054	84.120	Lower Silurian.
614	Franklin,	.897	4.475	3.611	5.740	7.085	.445	.383	.222	.316	.101	.173	.048	82.450	Lower Silurian, sub-soil.
619	Gallatin,	2.908	5.575	7.005	5.965	6.035	.920	768	.320	.360	.114	.486	.013	77.770	Lower Silurian.
620	Gallatin,	3.441	6.000	6.543	5.715	6.170	.970	.818	.595	.310	.079	.354	.021	77.855	Lower Silurian, sub-soil.
621	Garrard,	7.634	5.825	8.548	6.190	3.920	1.910	.763	.520	.559	.128	.393	.081	77.380	Lower Silurian.
622	Garrard,	4.586	4.550	5.238	7.805	5.165	3.270	1.358	.649	.484	.059	.386	.025	75.570	Lower Silurian.
623	Garrard,	3.186	4.950	4.234	8.577	5.745	3.880	1.476	.590	.513	.059	.354	.059	74.780	Lower Silurian, sub soil.
624	Garrard,	4.992	3.350	4.640	3.140	2.875	.420	.692	.270	.379	.102	.121	.045	88.220	Lower Silurian.
625	Garrard,	3.343	3.365	4.987	3.040	3.844	.385	.207	.110	.335	.067	.106	.057	87.170	Lower Silurian.
626	Garrard,	1.409	2.915	2.945	3.815	3.290	.170	.412	.210	.251	.042	.020	.018	89.095	Lower Silurian, sub soil.
627	Grant,	3.170	3.150	5.212	2.530	2.595	.247	.472	.222	.283	.093	.186	.083	87.845	Lower Silurian.
628	Grant,	2.590	3.135	4.572	3.520	3.115	.247	.433	.222	.135	.080	183	.071	87.595	Lower Silurian.
629	Grant,	1.428	2.415	3.111	3.745	3.425	.147	.379	.212	.244	.045	.222	.052	88.650	Lower Silurian, sub-soil.
630	Grant,	2.743	3.225	6.162	2.815	2.734	.196	.399	.170	.203	.072	.133	.113	87.045	Lower Silurian.
636	Hancock,	4.890	3.325	6.022	2.295	2.390	.310	.334	.145	.196	.096	.250	.054	87.910	Coal Measures.
637	Hancock,	1.820	3.415	2.883	2.120	2.430	.240	.278	.260	.063	.067	.174	.066	91.070	Coal Measures.
638	Hancock,	1.128	3.175	3.020	4.190	4.865	.130	.605	.070	.107	.101	.219	.055	86.645	Coal Measures, sub soil.
641	Hardin,	2.078	3.760	5.069	1.936	2.860	.270	.388	.236	.396	.054	.208	.006	88.096	Sub carboniferous.
642	Hardin,	1.466	1.600	2.443	1.715	1.440	.022	.209	.095	.079	.016	.167	.032	93.020	Sub carboniferous.
643	Hardin,	2.742	1.965	3.417	2.245	2.075	.197	.203	.095	.177	.067	.104	.013	91.445	Sub-carboniferous.
644	Hardin,	1.992	1.500	2.309	1.745	1.420	.097	.191	.040	.078	.021	.075	.030	93.495	Sub-carboniferous.
645	Hardin,	2.093	1.965	2.407	2.670	2.415	.147	.325	.070	.096	.028	.092	.024	91.395	Sub-carbonif'rs. sub-soil.
646	Harrison,	4.847	3.325	7.721	3.540	3.865	.466	.483	.420	.394	.114	.170	.077	82.895	Lower Silurian.
647	Harrison,	4.077	2.750	6.051	3.655	3.835	.296	.463	.480	.385	.107	.159	.105	84.630	Lower Silurian.
648	Harrison,	3.093	2.825	5.119	3.565	3.660	.313	.491	.345	.316	.101	.151	.090	85.710	Lower Silurian, sub-soil.
649	Henry,	4.617	4.075	5.180	2.515	3.940	.372	.503	.170	.615	.101	.284	.132	85.900	Lower Silurian.
650	Henry,	2.439	3.935	5.159	3.915	4.115	.496	.558	.220	.407	.111	.298	.133	83.760	Lower Silurian.
651	Henry,	3.382	4.110	4.918	4.125	4.545	.396	.612	.160	.448	.085	.297	.067	84.943	Lower Silurian, sub soil.

TABLE 1—Continued. Soils, Sub-soils, and Marls.

Number in the report.	County.	Dissolved from 1000 grains by carbonated water.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia and carbonate.	Oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Formation, &c.
659	Jefferson,	1.822	3.100	4.231	3.580	4.421	0.220	0.359	0.445	0.262	0.084	0.167	0.045	86.066	Sub carboniferous.
660	Jefferson,	5.194	3.175	4.983	3.245	4.130	.195	.335	.370	.295	.085	.213	.051	85.895	Sub carbonif'rs, sub-soil.
662	Jessamine,	4.210	2.900	4.737	2.695	2.890	.345	.199	.280	.133	.067	.121	.047	87.995	Lower Silurian.
663	Jessamine,	3.212	2.950	4.250	3.695	3.240	.295	.366	.285	.239	.050	.185	.044	87.245	Lower Silurian.
664	Jessamine,	3.985	4.200	5.349	5.065	4.900	.595	.750	.220	.666	.106	.344	–	81.720	Lower Silurian.
665	Jessamine,	8.083	6.775	9.745	9.190	5.840	3.570	1.290	.470	.532	.119	.569	.212	69.070	Lower Silurian.
667	Kenton,	2.460	3.935	5.429	3.255	2.520	.197	.461	.189	.226	.076	.272	trace.	87.445	Lower Silurian.
668	Kenton,	1.705	3.210	3.621	3.570	3.245	.147	.460	.345	.206	.074	.212	.035	87.495	Lower Silurian.
669	Kenton,	1.630	3.165	2.901	3.660	3.220	.147	.478	.320	.150	.050	.205	.060	88.745	Lower Silurian, sub-soil.
670	Larue,	1.586	2.625	6.428	3.175	2.715	.072	.290	.230	.114	.050	.135	.025	88.680	Sub carboniferous.
671	Larue,	1.970	2.425	5.380	3.175	2.815	.106	.342	.245	.113	.055	.123	.021	89.340	Sub carboniferous.
672	Larue,	1.134	2.725	2.981	3.955	3.265	.015	.467	.235	.096	.050	.130	.023	88.625	Sub carbonif'rs, sub-soil.
673	Marion,	3.409	3.375	4.786	6.495	3.565	.222	.339	.271	.262	.042	.157	.011	85.040	Devonian?
674	Marion,	4.478	3.400	4.748	3.940	4.970	.222	.302	.312	.2[illegible]0	.062	.181	.033	84.720	Devonian?
675	Marion,	1.360	3.200	3.679	4.645	5.360	.297	.372	.172	.279	.042	.212	.019	84.720	Devonian? sub-soil.
676	Meade,	1.627	2.840	3.911	1.896	2.040	.136	.205	.036	.151	.041	.259	.042	91.436	Sub-carboniferous.
677	Meade,	1.205	2.320	2.620	3.136	2.580	.236	.298	.116	.125	.130	.154	.084	91.036	Sub carboniferous.
678	Mercer,	5.200	4.500	6.361	3.955	4.050	.495	.341	.345	.309	.076	.144	.024	83.712	Lower Silurian.
679	Mercer,	5.310	4.000	5.208	3.590	3.790	.385	.365	.295	.397	.098	.130	.036	86.250	Lower Silurian.
680	Mercer,	4.000	3.700	4.389	3.750	3.415	.395	.390	.320	.362	.050	.114	.040	86.720	Lower Silurian, sub soil.
681	Mercer,	11.095	4.500	10.365	5.395	7.110	1.995	1.234	.620	.333	.093	.762	.106	72.035	Lower Silurian.
682	Mercer,	3.754	4.375	6.980	7.495	7.270	2.080	1.184	.645	.298	.090	.705	.106	72.810	Lower Silurian.
683	Mercer,	6.157	5.000	7.252	8.315	7.335	2.850	1.477	.769	.459	.058	.650	.050	71.395	Lower Silurian, sub-soil.
684	Mercer,	5.818	4.450	5.494	6.195	5.184	14.170	.604	.490	.456	.041	.817	.123	66.245	Lower Silurian, un. clay
714	Nelson,	5.855	4.985	6.659	4.655	4.065	.770	.452	.395	.535	.093	.222	.026	82.195	Lower Silurian.
715	Nelson,	2.389	2.700	3.423	3.140	2.825	.330	.282	.280	.316	.078	.130	.036	88.895	Lower Silurian.
716	Nelson,	1.579	2.850	2.804	3.490	3.370	.230	.254	.220	.277	.059	.101	.034	88.970	Lower Silurian, sub soil.
717	Nelson,	1.620	5.575	4.090	8.240	7.065	1.725	.731	.380	.438	.059	.334	.032	77.275	Lower Silurian.
718	Nelson,	1.746	5.050	4.449	7.290	6.015	.590	.967	.295	.368	.033	.283	.058	79.730	Lower Silur., shell earth.
719	Nelson,	4.816	3.750	5.298	3.890	3.875	.270	.416	.420	.114	.051	.098	.036	85.895	Upper Silurian.
720	Nelson,	5.032	3.425	5.384	4.280	3.905	.405	.492	.470	.228	.117	.193	.049	84.395	Lower Silurian.

721	Nelson,	3.842	3.250	4.858	4.070	3.995	.222	.553	.295	.351	.067	.298	.015	85.585	Lower Silurian.
722	Nelson,	2.000	4.000	4.088	5.910	5.160	.336	.487	.320	.345	.065	.275	.055	83.210	Lower Silurian, sub soil.
723	Nelson,	1.956	5.275	6.280	9.325	7.885	.645	1.100	.295	.773	.062	.449	.272	73.095	Under shell earth.
724	Nelson,	5.892	2.575	7.195	3.295	3.110	.445	.522	.195	.342	.096	.154	.021	84.595	Lower Silurian.
725	Nelson,	4.895	2.640	7.164	3.495	3.535	.520	.656	.220	.343	.067	.125	.027	83.770	Lower Silurian.
726	Nelson,	-	-	-	11.850		.393	.966	-	.121	.463	.749	.482	84.990	Marl, sub carboniferous.
728	Nelson,	-	-	1.127	9.430		.843	1.533	-	.144	.227	.657	.229	85.840	Marl, sub carboniferous.
729	Nelson,	-	-	4.200	5.190	4.650	.396	.613	.230	.172	.085	.282	.095	84.495	Lower Silur, shell earth.
734	Oldham,	2.100	3.000	4.778	2.214	2.240	.340	.328	.172	.251	.067	.125	.027	89.420	Upper Silurian.
735	Oldham,	1.547	2.200	3.001	2.270	2.020	.170	.275	.145	.128	.076	.111	.039	91.295	Upper Silurian.
736	Oldham,	1.237	2.575	2.643	3.355	2.540	.125	.365	.145	.112	.050	.130	trace.	89.820	Upper Silurian, sub soil.
737	Oldham,	3.100	1.475	2.537	1.120	2.625	.239	.233	.072	.107	.079	.075	.056	92.747	Upper Silurian.
738	Owen,	1.850	3.225	3.978	3.970	3.290	.180	.444	.335	.179	.054	.256	.024	87.195	Lower Silurian.
739	Owen,	0.980	3.250	3.256	3.995	3.290	.145	.388	.180	.163	.050	.179	.017	88.170	Lower Silurian.
740	Owen,	1.501	3.050	3.146	4.343	3.515	.195	.441	.265	.163	.044	.262	.006	87.360	Lower Silurian, sub soil.
743	Pendleton,	3.354	2.450	4.766	2.290	2.685	.296	.157	.145	.227	.107	.207	.078	88.010	Lower Silurian.
744	Pendleton,	2.649	2.675	4.906	2.565	2.510	.275	.341	.145	.178	.055	.140	.037	88.570	Lower Silurian.
745	Pendleton,	2.183	2.450	3.459	3.500	3.200	.162	.685	.146	.195	.089	.188	.068	88.010	Lower Silurian, sub soil.
748	Scott,	6.114	5.450	9.042	5.025	5.310	1.020	.293	.565	.438	.141	.214	.106	78.145	Lower Silurian.
749	Scott,	6.578	3.400	5.197	5.425	5.110	1.195	.504	.502	.319	.179	.197	.125	81.260	Lower Silurian.
750	Scott,	3.599	3.415	4.669	6.740	5.735	.595	.581	.397	.323	.136	.183	.031	81.880	Lower Silurian, sub-soil.
751	Shelby,	-	3.700	3.193	13.130		1.290	.914	-	.284	.066	.395	.038	80.690	Lower Silurian, a marl.
752	Shelby,	2.010	3.565	4.648	2.895	3.280	.320	.406	.170	.249	.064	.159	.026	87.222	Lower Silurian.
753	Shelby,	1.851	3.400	4.503	3.070	3.190	.495	.366	trace.	.152	.050	.128	.051	88.050	Lower Silurian.
754	Shelby,	1.117	3.350	3.336	3.174	4.080	.235	.354	.045	.196	.059	.214	.014	88.445	Lower Silurian, sub-soil.
755	Shelby,	3.128	3.575	4.734	4.590	3.585	.445	.533	.270	.479	.128	.120	.097	85.670	Lower Silurian.
756	Shelby,	4.279	3.225	4.970	4.115	3.660	.546	.497	.515	.259	.067	.173	.093	84.970	Lower Silurian.
757	Shelby,	1.614	2.925	3.245	4.690	3.865	.246	.558	.395	.393	.050	.208	.051	86.320	Lower Silurian, sub-soil.
758	Spencer,	2.798	3.350	4.317	3.096	2.590	.345	.493	.515	.187	.059	.236	.014	87.970	Lower Silurian.
759	Spencer,	2.111	2.425	2.973	2.496	2.640	.245	.241	.170	.144	.041	.183	.047	90.095	Lower Silurian.
760	Spencer,	1.050	3.075	2.347	2.665	3.175	.220	.454	.164	.106	.062	.154	.030	90.320	Lower Silurian, sub soil.
761	Spencer,	-	-	3.256	12.655		5.890	carbont. .979	-	.123	.485	.424	.148	76.040	Lower Silurian, marl.
762	Taylor,	5.145	2.850	7.075	3.765	3.110	.172	.435	.095	.146	.103	.146	.046	85.345	Sub carboniferous.
763	Taylor,	4.654	2.425	5.816	2.530	2.910	.122	.423	.120	.105	.067	.125	.052	87.330	Sub-carboniferous.
764	Trimble,	3.382	2.500	4.308	2.530	1.990	.320	.232	.170	.089	.033	.213	.047	90.195	Upper Silurian.
765	Trimble,	2.499	2.450	3.434	2.995	2.890	.220	.291	.170	.096	.020	.152	.049	89.920	Upper Silurian.
766	Trimble,	3.029	2.425	3.136	3.470	2.640	.170	.294	.245	.079	.015	.181	.028	90.160	Upper Silurian, sub soil.
767	Union,	1.928	3.500	3.720	3.465	2.920	.624	.630	.950	.196	.067	.133	.104	87.510	Coal Measures.

TABLE 1—Continued. SOILS, SUB-SOILS, AND MARLS.

Number in the report	County.	Dissolved from 1000 grains by carbonated water.	Moisture.	Organic and volatile matters.	Alumina.	Oxide of iron.	Carbonate of lime.	Magnesia and carbonate.	Oxide of manganese.	Phosphoric acid.	Sulphuric acid.	Potash.	Soda.	Sand and silicates.	Formation, &c.
768	Union,	-	-	2.309	3.910		.590	.466	-	-	.124	.188	.213	92.120	Coal Meas. .080 chlorine.
769	Union,	0.866	3.500	3.333	4.290	5.365	trace.	.541	.495	.162	.076	.231	.111	85.330	Coal Measures.
770	Washington,	6.750	5.050	7.753	3.790	3.930	.636	.333	.495	.488	.084	.231	.030	82.190	Lower Silurian.
771	Washington,	3.712	3.555	5.635	4.515	4.145	.396	.233	.420	.445	.067	.191	.011	83.940	Lower Silurian.
772	Washington,	1.865	3.450	3.340	4.565	4.385	.290	.308	.345	.346	.042	.160	.038	86.175	Lower Silurian, sub-soil.
773	Washington,	3.982	3.300	4.576	3.440	2.990	.322	.388	.170	.196	.067	.154	.021	87.410	Lower Silurian.
774	Washington,	2.306	2.150	3.055	3.015	3.390	.222	.344	.175	.161	.059	.132	.035	89.070	Lower Silurian.
775	Washington,	1.640	2.890	2.894	3.565	3.440	.145	.443	.170	.129	.077	.128	.052	89.020	Lower Silurian, sub-soil.

TABLE 2.

Limestones, &c.

Number in the report.	County.	Specific gravity.	Carbonate of lime.	Carbonate of Magnesia.	Lime.	Magnesia.	Carbonic acid.	Alumina, oxide of iron & manganese.	Phosphoric acid.	Sulphuric acid.	Carbonate or oxide of iron.	Potash.	Soda	Bituminous matters.	Silica, &c.	Remarks.
572	Bourbon,	-	81.34	0.979	45.645	-	-	0.640	0.221	0.324	-	0.104	0.177	-	16.646	Lower Silurian.
573	Bourbon,	-	94.680	.980	53.130	-	-	1.120	.196	.592	-	.166	.233	-	1.086	Lower Silurian.
578	Bourbon,	-	97.540	.699	53.735	-	-	.287	.093	.180	-	.065	.206	-	1.446	Lower Silurian.
579	Bourbon,	-	95.480	1.398	53.580	-	-	.797	.183	.180	-	.085	.135	-	2.360	Lower Silurian.
605	Franklin,	-	95.150	2.550	53.390	-	-	.870	.080	.850	-	.230	.230	-	0.580	Lower Silurian.
615	Franklin,	-	95.380	1.510	53.522	-	-	.769	.311	.579	-	.108	.003	-	2.080	Lower Silurian.
616	Fayette, A.	2.728	59.880	37.050	-	-	-	1.380	-	-	-	.610	.420	-	2.080	Do. (Magnesian.)
	Fayette, B.	2.767	64.400	33.900	-	-	-	.950	-	-	-	not es.	not es.	-	2.000	
617	Fayette,	-	97.820	.839	-	-	-	.480	.118	.235	-	.166	.020	-	.527	Fossil Chætetes.
658	Hopkins,	2.778	23.790	4.413	-	carb. mangan.	0.580	Alumi. 1.590	.247	.006	11.717	.270	.091	2.170	55.120	Coal Measures.
666	Jessamine,	-	92.980	8.390	52.176	-	-	2.040	.567	.133	-	.166	.055	-	3.146	Lower Silurian.
685	Mercer,	-	88.900	1.468	49.855	-	-	2.340	.631	.235	-	.168	.053	-	7.186	Lower Silurian.
705	Muhlenburg,	2.777	82.880	4.196	46.509	-	-	4.330	.247	4.717	-	.135	.150	-	4.280	Coal Measures.
709	Nelson,	2.758	62.190	33.900	34.900	-	-	.680	-	-	-	.460	.350	-	3.180	Upper Silurian.
711	Nelson,	-	51.660	32.000	29.000	-	-	5.550	-	.090	-	.770	.460	-	9.780	Denovian.
732	Nicholas,	-	78.680	1.566	44.150	-	-	2.480	.247	.270	-	.173	.172	-	16.640	Lower Silurian.
742	Owen,	-	92.920	.559	52.139	-	-	3.580	.349	.338	-	.162	.160	-	1.720	Lower Silurian.
776	Woodford,	2.655	59.860	36.640	33.590	17.440	-	.980	-	.160	-	.409	.080	-	2.480	Do. (Magnesian.)

TABLE 3.

Iron Ores. (A.) Limonites.

Number in report.	County.	Specific gravity.	Peroxide of iron.	Carbonate of iron.	Brown oxide of manganese.	Carbonate of lime.	Magnesia.	Alumina.	Phosphoric acid	Sulphuric acid.	Sulphur.	Potash.	Soda.	Combined water.	Silica, &c.	Per centage of iron.	
589	Bullitt,	-	33.990	-	0.480	trace.	0.680	1.580	not est.	-	.350	0.440	0.230	6.750	56.130	23.800	Bullitt's Lick.
609	Franklin,	-	26.690	-	3.680	-	1.150	-	0.630	-	.050	.630	trace.	7.500	52.680	18.690	
634	Greenup,	-	20.870	-	.180	trace	3.240	.690	.310	-	.250	.380	.100	3.150	60.028	14.610	Raccoon Furnace.
635	Hancock,	-	34.600	-	-	trace.	.500	1.380	-	-	.060	.670	.170	6.500	55.580	24.230	
653	Hopkins,	2.785	54.080	-	.720	trace.	.244	1.380	1.400	-	.210	.251	.055	7.180	34.480	37.870	
654	Hopkins,	-	62.250	-	.860	2.040	6.432	5.820	1.170	-	.356	.571	trace.	8.800	12.180	43.593	
655	Hopkins,	4.563	91.780	-	.486	trace.	.221	1.035	.055	-	.310	.154	.029	1.140	5.286	64.266	
698	Morgan,	-	22.040	15.340	1.020	1.640	2.920	.810	.370	-	.270	.170	.310	.630	54.480	22.100	
727	Nelson,	-	39.340	-	1.180	.886	Carbonat 4.827	2.560	.315	.201	-	.668	.342	4.961	44.720	27.550	
746	Rowan,	2.868	26.680	-	.260	-	.330	.980	-	-	.050	.570	-	2.800	68.910	-	
747	Rowan,	3.261	56.140	-	.380	-	.180	.960	-	-	-	.210	.110	1.600	31.780	39.310	

TABLE 3.

Iron Ores. (B.) Carbonate of Iron.

Number in the report.	County.	Specific gravity.	Carbonate of iron.	Oxide of iron.	Carbonate of lime.	Carbonate of magnesia.	Carbonate of manganese.	Alumina.	Phosphoric acid.	Sulphur.	Potash.	Soda.	Bituminous matter.	Silica, &c.	Water.	Per centage of iron.
600	Estill,	-	52.600	13.640	1.000	3.960	1.180	1.010	0.370	0.130	0.250	trace.	-	20.780	5.700	42.720
632	Greenup,	-	42.260	46.650	.480	.380	1.480	.380	.760	.090	-	-	-	2.980	4.000	52.950
633	Greenup,	-	51.240	9.420	.680	2.760	1.310	1.090	.640	.090	.150	0.230	-	32.480	-	31.620
756	Hopkins,	3.227	61.730	-	4.890	1.848	.887	.480	.183	.122	.201	.058	2.800	27.140	-	26.845
757	Hopkins,	3.146	45.119	16.457	4.780	5.616	2.093	.270	1.720	.212	.262	.097	-	19.920	3.454	33.860
708	Nelson,	5.201	33.500	5.500	4.580	9.820	.710	3.150	.630	.080	.480	.230	-	21.480	-	29.690
710	Nelson,	3.348	69.960	2.640	3.940	9.430	1.320	1.550	.630	.090	.340	.340	-	10.480	-	35.640

TABLE 4.

Coals.

Number in the report.	County.	Specific gravity.	Moisture.	Volatile combustible matt'rs.	Carbon in coke.	Ashes.	Total volatile matters.	Coke.	Sulphur.	Bituminous oil for 1000 grains.	Designation.
686	Morgan,	1.365	0.80	45.00	32.70	21.50	45.80	54.20	0.90		Crow's Cannel.
687	Morgan,	1.280	3.00	36.60	58.10	2.30	39.60	60.40	1.15	234 grains.	Crow's Bituminous.
688	Morgan,	1.360	1.90	45.30	31.80	21.00	47.20	52.80	0.87	-	Crow's Cannel.
639	Morgan,	1.328	3.00	40.00	44.00	13.00	43.00	57.00	0.82	-	Cannel, (Barber's.)
690	Morgan,	1.307	2.50	40.50	48.70	8.30	43.00	57.00	1.26	-	Cannel, (Crow's.)
691	Morgan,	1.336	3.30	36.40	55.60	4.70	39.70	60.30	0.74	-	Bituminous, (Crow's.)
692	Morgan,	1.327	5.00	37.80	46.60	10.60	42.80	5[illegible].20	0.63	-	Cannel, (Barber's.)
693	Morgan.	1.299	2.60	37.00	45.40	5.00	39.60	60.40	0.54	-	Bituminous, (Smedley's.)
694	Morgan,	1.542	1.00	37.60	31.40	30.00	38.60	61.40	1.23	-	Cannel, (Crow's.)
695	Morgan,	1.288	1.40	44.40	4 .00	6.20	45.80	54.20	0.68	176 grains.	Cannel, (Schoolfield's.)
696	Morgan,	1.345	3.00	39.60	48.20	9.20	42.60	57.40	4.84	-	Bituminous.
697	Morgan,	1.296	2.70	42.90	50.40	4.00	45.60	54.40	2.42	-	Bituminous.

TABLE 5.

Sandstones and Shale.

Number in the report.	County.	Sand and silicates.	Carbonate of lime.	Carbonate of magnesia.	Alumina and oxide of iron.	Oxide of manganese.	Phosphoric acid	Sulphuric acid.	Potash.	Soda.	Water.	
610	Franklin,	80.680	0.990	2.440	9.470	-	0.180	2.600	2.370	0.130	1.140	Sandstone.
631	Grant,	89.620	.563	.766	6.202	-	.378	.107	.363	.200	1.950	Sandstone.
699	Morgan,	84.380	1.760	1.080	12.780	-	-	-	-	-	-	Ferruginous sandstone.
730	Nicholas,	93.390	.113	.199	4.140	-	.092	.076	2.020	.121	1.667	Lower Silurian.
731	Nicholas,	88.440	.743	.322	8.560	.290	.572	.100	.473	.233	-	Lower Silurian.
741	Owen,	88.090	1.193	1.600	6.320	.210	.860	.184	.602	.212	.699	Lower Silurian.

TABLE 6.

Iron Furnace Slags.

Number in the report.	County.	Silica.	Alumina.	Lime.	Magnesia.	Protoxide of iron.	Protoxide of manganese	Potash.	Soda.	Oxygen in the silica.	Oxigen in the bases.	Proportion of oxygen in the bases to O in the silica.	Furnace.
706	Muhlenburg,	42.080	23.080	24.230	6.103	1.044	1.023	2.066	0.599	21.849	21.076	1 : 1.036	Airdrie.
712	Nelson,	53.524	19.957	14.000	5.706	2.673	.059	3.244	1.401	27.793	17.105	1 : 1.624	Nelson.

TABLE 7.

Pig Iron.

Number in the report.	County.	Specific gravity.	Iron.	Graphite.	Combined carbon	Total carbon.	Manganese.	Silicon.	Slag.	Aluminium.	Calcium.	Magnesium.	Potassium.	Sodium.	Phosphorus.	Sulphur.	Furnace.
707	Muhlenburg,	7.0067	88.428	1.360	0.196	1.550	0.980	6.216	3.090	0.099	trace.	0.309	0.059	0.091	0.209	0.219	Airdrie.
712	Nelson,	7.1493	95.173	2.880	-	2.880	.274	.697	.190	.101	0.025	.114	.096	.026	.339	.096	Nelson.

CONTINUATION FROM VOL. 2,

OF THE

TOPOGRAPHICAL GEOLOGICAL REPORT

OF THE PROGRESS OF THE

SURVEY OF KENTUCKY,

IN THE COUNTIES OF

GREENUP, CARTER, LAWRENCE AND HANCOCK,

FOR THE YEAR 1857,

BY

SIDNEY S. LYON,

TOPOGRAPHICAL ASSISTANT.

CHAPTER I.

OBSERVATIONS ON THE GEOLOGY AND TOPOGRAPHY OF GREENUP COUNTY.

In my previous report on the progress of that part of the Geological Survey of Kentucky confided to my direction, the observations of Greenup county were set forth to the extent they had been made up to that time.

During the present season, corps No. 3, under the direction of Mr. Edward Mylotte, has extended the field work. The topography and geography of that county has been completed, except a narrow strip along the western margin of the county, including only the heads of some of the longer branches of Tygert's creek. The topographical work has been extended also across Carter county, east of Little Sandy river, as well as some distance into Lawrence county. For the extent and completeness of this work, I refer to the map of the survey accompanying this part of my report.

The observations on the eastern coal and iron region made last year were not sufficiently numerous, or in such close connection, as to warrant any safe general conclusions. The observations for the stratigraphical and geological features of this district have been very much extended during the present season, and a few deductions of a general character are here presented.

1. That the margin of the Eastern Coal-field of Kentucky, on the west, nearly coincided with the ridge of high land dividing the waters of Tygert's and Kinniconick creeks; and on the north the margin line nearly coincided with the present line of the Ohio river, from the mouth of the Scioto river to the mouth of Little Sandy river.

2. That the disturbing forces, operating during the deposition of the carboniferous formation of Greenup and Carter counties acted with very great energy along this margin, and that it was sustained nearly at the level of the water of the then existing sea, during the whole carboniferous period.

3. That the greatest subsidence occurred to the south-east and south-west, from the mouth of Little Sandy.

4. That the sea bottom, at the period immediately succeeding each subsidence, was very unequal, and waving, making long troughs and ridges alternately; and that, to a greater or less extent, this condition existed at every subsidence, with, however, this difference—the ridges of one period seldom agreeing with those of the period immediately preceding it, and not unfrequently the ridges of one period lie diagonally across the waves of the preceding one.

5. That as these periods of depression, and upheaval, succeeded each other, the rushing currents of water frequently wasted and carried away part of a bed and deposited the wasted materials in another place.

6. That the period of the formation of the several beds of iron stones, was one of general submergence, proved by the continuity of the beds over wide areas.

7. The character of the beds were much modified by the currents, sometimes transporting and mixing sand, and other transported materials, with the ferruginous deposits, and sometimes sweeping the beds previously formed, either entirely away, or leaving them merely in holes and pockets, formed by the inequalities of the original sea bottom.

8. That the final upheaving force, by which these measures were raised to the position they now occupy, many hundred feet above the level of the present seas, produced by lines of fracture, along which the course of the larger streams was determined, as well as a majority of the branches and drains, notwithstanding the immense denudation, there is no evidence that any branch, or stream, has been produced alone by the wasting force of running water.

9. That the forces producing the final elevation of the Coal Measures of Greenup and Carter counties, acting in lines of unequal force, has raised the high lands between the larger streams into ridges of curved and bent rocks, and associated materials—always making the dividing ridge between parallel streams higher from the bed of the stream to the top of the ridge, than the thickness of the rocks, &c., composing the ridge; the height of the hills always exceeding the thickness of the rocks, by the amount of the dip of the rocks from the center of the top of the hill to the bed of the stream. Furthermore, the waves producing the main and subordinate ridges, have been

crossed by a force which has thrown the great hills into waves of greater or less length. This last force appears generally to have crossed the lines of the first waves nearly at right angles. In a few instances, instead of waves and undulations, faults have been produced. It is to the effect of these two lines of undulatory motions, that are to be traced one of the most remarkable features of the country—the "low gaps;" at which places the main ridges are nearly severed, sometimes bent down, and sometimes broken by a fault; in which one side of the gap appears to hold the normal height of the ridge, while the other side has fallen towards the gap, from 75 to 300 feet. The faults are the exception, the waving and bent stratification is the rule.

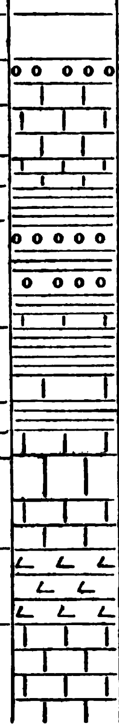
From a careful consideration of the preceding propositions, it will be seen that each hill and valley of this country becomes in itself a special study. There are a few rules which have been found useful in the investigation of this country. If the measures are not exposed, there are in them several beds of alternately soft and hard materials, marking the hills with a succession of benches. The line of dip, with a few exceptions, is with the line of the creeks and valleys. The dip is also nearly always from the centre of the ridges towards the valleys. Pine trees universally mark the debris of coarse sandstones. Spruce and hemlock locally marks the millstone grit. Chestnut oak always marks heavy deposits of clay. These characteristics have a local application, and will hold good in the Coal Measures of Greenup and Carter counties.

The sandstones at the top of the Knobstone formation produces pine. The next sandstone in the ascending series, producing this tree, is the mass over the coal at Clinton Furnace, and upper bed at Ashland. The third sandstone, in ascending order, marked by pine, is the sandstone over the bed called the limestone ore of Laurel, Steam and Caroline Furnaces. There is still another sandstone marked by its belt of pine trees. This last lies high in the hills, and has been observed in but few places. A small point of a ridge at the head of Key's creek, on the rounded hill south of the Pike, near Mr. Scott's, on the highest points at the head of Stinson's creek, in the vicinity of Caroline Furnace, and at the head of Indian creek, are the only places where this member has been noticed.

STRATIGRAPHICAL ARRANGEMENT AND EQUIVALENT BEDS OF DIFFERENT LOCALITIES.

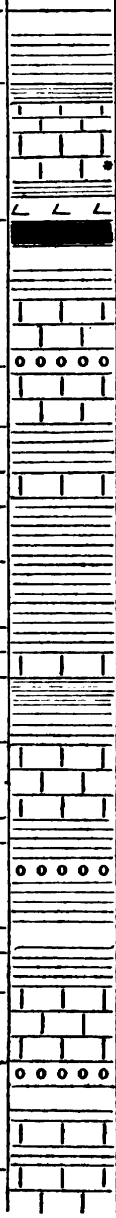
The following sections will partially exhibit the changes in equivalent members, and may serve as the key by which the beds of ore may be traced along the sides of the valleys, and sought for in their true geological horizon. It is to be observed, however, that the character of the ores and associated materials are much changed, even in inconsiderable distances. The horizontal place of a given bed is, also, much modified from a given locality. On descending a branch the bed is found to descend with the line of the valley. It may be expected that the bed will be found occupying a higher position on ascending the same valley. Further, as the line of stratification curves with the line of the sag of the ridges, so the ore beds are also depressed with the rocks between which they lie.

No. 1. Section of the measures at Kenton Furnace.



Feet.	Inches.	Feet.	Inches.	
460		29		Covered space.
417		87	6	Scattered patches of kidney ore. Micaceous sandstone and sandy shales.
329	6	12		Sandstone beds used in building furnace stack. Bed of clay, probably the waste of clay slate. Top hill "Block ore." Soft, with light colored ochreous specks.
317	6	23	6	Covered space, probably, slate and shales.
294		7		Top of seven feet, kidney ore beds.
287		15		"Little Block" ore, 4 to 6 inches thick. Space, with shale. "Rough Block," 9 to 18 inches thick.
272		5		Sandy shales.
267	1	8	1	"Hearth Rock" beds.
258	11	16	11	Rough, coarse sandstone.
247		7	9	Ore bed resting on the sub-carboniferous limestone at Boone and Kenton Furnaces.
238				Sub-carboniferous limestone.
10		238		Knob freestone and shale, equivalent to the rocks of Triplett and Kinniconick creeks.
		10		Base of furnace stack, resting on Knobstone beds.
		0		Bed of White Oak creek.

No. 2. Section of the measures equivalent to those at Kenton Furnace as seen at Laurel Furnace. See map of Greenup county for relative position of places.



Feet.	Inches.	Feet.	Inches.	
465	6	89	6	Top of hills. The upper 89 feet local; capping only a few of the hills. Covered space, probably clays. Timber, chestnut oak.
376	6	4		Dark argillaceous shales, varying from 4 to 30 feet.
		25		Sandstone, fine grained. This rock is local, and varies from a few inches in thickness, to 25 or 30 feet thick, frequently pebbly.*
		15		Dark clay, from 1 to 30 feet. Limestone ore. *Baker Bank.*
367	8			Coal 1 inch to 4 inches thick. Under clay, from 1 to 4 feet thick. Slope, with shale and sandstone at base, from 1 to 10 feet thick.
		38		*Place of Red and Buck Smith Banks.*
329	8	10		Top of bench, probably sandstone.
319	8	5		Clay bed. Sandy shales.
314	8	1	2	Hard sandstone.
313	6	15		Sandy and clay shales.
		4		Clay bed.
289	6	30		Sandy shales.
285	6			
255	6	5		Bed of flag stone.
250	6	21		Black clay shale 4 to 5 feet. Shaley sandstones 16 feet.
229	6	15		Soft coarse sandstone, equivalent to the bed used at Raccoon Furnace for bosh stone. Lower part strongly marked by oblique lines of deposition.
214	6			
187	6	27		Drab micacious sandy shales. Thin bed 3 to 5 inches—sandy, kidney and block ores.
		10		Drab, sandy, micacious and clay shales, alternating.
177	6	10	8	Covered space.
166	10	30		Drab sandy shales.
136	10	43	2	Hearthstone bed of Laurel Furnace, equivalent bed used at Raccoon Furnace for hearth rock. Lower part shaley sandstone.
93	8	17		Lowest ore bed known at Laurel Furnace. Rough blocks, and generally sandy. Shaley sandstone and shales.
76	8	5	4	Sandstone.

*This rock has been used for hearth.

Feet.	Inches.	Feet.	Inches.	
			16	Flagstones, thin beded, 2 to 6 inches thick.
55	4	5	4	Sandstone.
0				Top of stack, Laurel Furnace.
10		10		Thin beded hard sandstone.
16		6		Six feet ledge.
23		7		Seven feet ledge.
31		8		Eight feet ledge.
40		9		Nine feet ledge.
50		10		Lowest rock seen at Laurel, 50 feet below the top of stack.
		?		Probable equivalent of the millstone grit. Locally a bed of shales and small coal.
		?		Fire clay.
		?		*Sub-carboniferous limestone.
		?		

*See Sections Nos. 12, 1 and 16.

No. 3. Section at Raccoon Furnace, from Ruccoon creek towards the northwest.

Feet.	Inches.	Feet.	Inches.	
311		5		Ferruginous conglomerate, "poor ore," top of dividing ridge between Raccoon and Alcorn creeks.
336		45		Place of *limestone ore beds* of Laurel, Steam, and Caroline Furnaces. Covered space, mostly argillaceous shales.
291		20		Shale, sandstone and clay beds exposed at Triplett's bank.
271		16		Company's ore bank, 10 inches to 2 feet. †Place of principal ore beds ot Racooon and Buffaloe Furnaces. Thin beded, soft micaceous sandstone.
255		41		Bluff of heavy sandstone, top and bottom thin beded; middle of the mass very thick beded, composed of coarse angular sand and quartz pebbles, marked by ferruginous belts and patches.
214				Locally a thin coal.
		16		Covered space; soft beds, mostly argillaceous shales.

† The horizontal position occupied by equivalent ore beds, are severally thus: "Brown Bank," 295 feet, "Company Bank," 340 feet, "Tipton Bank," 350 feet. All these several openings are in one hill, and are highest to the west, or head of the creek.

Feet.	Inches.	Feet.	Inches.	
198		10	8	Sandy shales, part of the bed micaceous.
187	4	18		Thick, obscurely beded, *very* soft sandstone.
169	4	9		Soft sandstone, bedding well marked.
165	4	5		Sandy shales.
155	4	16		Sandy, poor ore, 6 inches thick, (not worked.) Covered space, showing in several places, thin bedded, muddy sandstones and sandy shales.
149	4	15	8	Coarse sandstone, evenly beded. Hearth rock of Raccoon Furnace, 18 inches thick.
133	8	5	4	Shale. Rock used in construction of stack, 18 inches thick, rough and ferruginous when weathered.
128	4	35		Sandy shales, with a few beds of sandstone intercalated.
93	4	10	8	Locally clay band, with thin coal. Thin beded soft sandstone and shales.
82	8	21	8	Covered space, mostly sandy shales.
60		7		Sandy ore, here 4 inches, ¼ of a mile east, 18 inches thick. Sandstone soft and imperfectly beded.
53		38		Ash colored and dark grey sandy shales with a few thin seams of argillaceous shale.
15		7	*	Bed of carbonate of iron. Dark grey shales, bed of Raccoon creek.
8				Bottom of pit 8 feet deep, bed of chert and silicious fire clay, resting on sub-carboniferous limestone ?
			0	

*See sections Nos. 15 and 16.

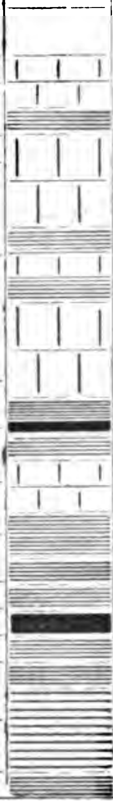
No. 4. Section at Steam Furnace, from stack to Carrington bank, southwestwardly.

Feet.	Inches.		Feet.	Inches.	
241	3		16		Clay and clay shales.
225	3		5		Little block ore. Clay bed, with kidney ore, ores not regularly bedded.
220	3		26		Coarse sandstone and conglomerate, over Carrington, or "Drift Bank."
194	3		3		Clay over limestone ore bed, from one inch to 30 feet thick.
191	3		1	3	Limestone ore, Carrington Bank. The ore bed varies in thickness from ½ inch to 4 feet thick.
190			5		Limestone used as a fluxing material. On the Steam Furnace lands it varies in thickness from one inch to 8 feet.
185			10	8	Clay beds over diggings west side of ridge.
174	4		16	2	Covered space, probably clay shale.
168	2		16		Clay shales, probably duplicate of the above.
152	2			*	Ore beds, block and kidney, from 6 to 15 inches thick, resting on clay containing black carbonaceous bands.
146	10		5	4	Sandstone.
141	10		5		Clay shale.
			38	2	Shales and shaley sandstones, alternating with beds of sandstone from 12 to 14 inches thick.
103	8		10	8	Top of sandstone above ore diggings, called "Little Block" ore.
93			32		Clay and micaceous sandy shale, exposed in ruts in the road.
61			5	†	Coal (?) dirt, covered by black bituminous shale. Under clay.
56			21		Clay shale, with intercalated beds of muddy sandy shales.
35			35		Sandstone.
			0		Quarry near Clerk's house. Office door.
6					Bed of branch.

*Equivalent to the main ore beds of Raccoon and Buffaloe Furnaces; and the Buck Smith and Red Banks of Laurel Furnace.

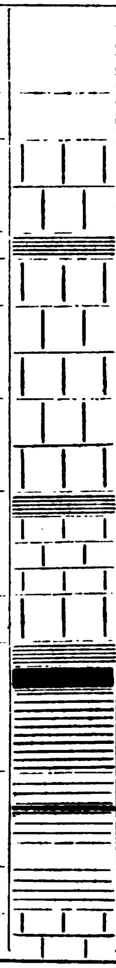
†Equivalent to the coal on Indian run—also, the coal at Caroline Furnace, and the upper coal of Clinton Furnace.

No. 5. Section from the west side of Little Sandy river, starting at 174 *feet of section No.* 6, *the bottom of this section being filled from section taken on the east side of the river, at Dr. Spalding's coal, in first hill south of Greenupsburg.*



Feet.	Inches.	Feet.	Inches.	
				Top of hill.
396	5	25		Coarse sandstone, containing pebbles and ferruginous bands, "pot ore."
371	5	35		Sandy shales, and covered space.
336	5	30	6	Hard, coarse sandstone, weathering into small holes, "honey-comb sandstone."
305	11	71	2	Shaley sandstone and sandy shales, with interculated beds of "flagstones."
234	9	6		Coarse sandstone, weathering into circular cavities 8 to 10 feet deep.
228	9	12		Hard thick bedded sandstone.
216	9	3		Black bituminous shale, over 8 inch coal.
213	9	42	9	Muddy sandy shales.
		6	5	Sandstone, equivalent to that at 174 feet, in Sec. No. 6.
171		57		Covered space, sandy and clay shales ?
114		6	8	Dove colored sandy shales.
107	4	2		Bitumicous shales.
105	4		9	Coal.
104	7	1	7	Silicious under clay.
103		61		Sandy and clay shales.
42		35		Sandy and clay shales, with thin flagstones intercalated, with a thin coal at its base, 1 to 3 inches thick.
7		7	0	Fire clay, 7 to 10 feet thick, (road-way.)

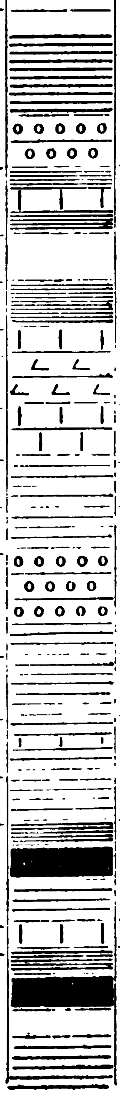
No. 6. *Section east side of Little Sandy river starting at surface of pool, 8 feet above low water of the Ohio river.*



Feet.	Inches.	Feet.	Inches.	
				Top of hills on the east side of Little Sandy river.
402	1	20		Sandstone.
382	1	5	1	Sandy shale, stained with ferruginous matter.
377		25		Heavy sandstone.
352		45	9	Coarse sandstone, containing quartz pebbles, especially at the junction of the beds; containing also much "*pot ore.*"
306	3	10	2	Coarse grey sandstone.
295	1	60		Covered space, composed of sandy and clay shales; 6 to 8 feet of sandstone exposed at the base of the mass.
236	1	5		Soft sandstone, weathering into circular cavities. Equivalent of rock at 234 feet, section No. 5.
231	1	10	2	Heavy compact sandstone.
220	11	66	1	Black bituminous shale. Thin coal, said to be 8 inches thick. Thin sandy shales, space partially covered. See section No. 5, for details of this space. Place of 174 feet in section No. 5.
154	10	101	8	Covered space, principally shale and shaley sandstone, with a *little* coal in the upper 50 feet. See sec. No. 5. Road from Greenupsburg to Raccoon Furnace.
53	2	43		Covered space, shales and clay.
10	2	10	2	*Knobstone in place—wedge shaped ledges.

*The millstone grit and sub-carboniferous limestone are both absent.

No. 7. Section at Caroline Furnace.



Feet.	Inches.	Feet.	Inches.	
250	8	10		Top of hills southwest of the furnace—the diving ridge between Indian creek, and the branches emptying into the Ohio. Rough "*Top Hill Block*," 8 to 15 inches thick, under kidney ore.
240	8	40		Shales and sandstone.
200	8	10		Covered space.
194	8	5		Argillaceous shale.
189	8	21		Soft sandstone.
168	8	10	8	Covered space, place of limestone ore, and limestone.
158		10		Sandstone, probably slipped from above.
141		10	8	Argillaceous shale.
130	4	5		Bed of fire clay (?)
				Place of ore bed at Steam Furnace, at 152 feet. See section No. 4. Equivalent to the main beds at Buffaloe and Raccoon Furnaces.
125	4	10	8	Ore diggings—no bed found, some loose ore from "*limestone ore*," at 168 feet 8 inches.
114	8	15	8	Soft sandy shales.
99		16		Clay bed at base of "bench."
83		36		Black clay bed, from 2 to 4 feet thick. *Place of Clinton Furnace coal* (?) Shale beds, and covered space.
47		37		Sandstone.
10		10		Black shales. *Coal. Under clay. Sandy shales. Bed of branch at stack.

*Equivalent to the Star, Steam, and Clinlon Furnaces, and Indian creek coal beds.

*No. 8. Section at Clinton Furnace.**

Feet.	Inches.		Feet.	Inches.	
					Top of hill north of furnace.
255	6		5		Red clay.
250	6		8		"Top hill" sandstone, 8 to 10 feet thick, sometimes filled with pebbles. *Horizon of pine trees.*
244	6	o o o o o	1		"Top hill" ore, 8 to 15 inches thick.
243	6		2		Sandstone.
241	6		5		Yellow sandy shale.
236	6		5	4	Sandstone.
231	2		4	8	Sandy shales.
190	6			8	Fossiliferous sandstone, shells converted into lime. "*Bastard limestone.*"
189	10		22		Sandy shale.
167	10		2		Band of black argillaceous shale.
165	10		6		Brownish red fire clay.
159	10			8	"*Red block ore,*" equivalent to limestone ore of Steam, Caroline, Belle Fonte, and Laurel Furnaces, forming the so-called 15 feet red streak.
159	2		10		Sandy shale.
149	2		5		Band of red clay, probably slipped from above.
144	2		16		Whitish argillaceous shale. Sandy shale.
128	2		10	8	Sandy shale.
117	6		1	4	Sandstone.
116	2		3		Shaley sandstone.
113	2	o o o o		8	Kidney, and "*bastard limestone ore,*" 8 to 10 inches thick.
102	6		16		Sandy shale.
86	6		26		Sandstone, 18 inches thick. Sandy shale.
60	6		17	4	Sandstone, one foot thick. Sandy shale.
43	2		10	4	Sandstone.
32	10	o o o o	12		Shales. "*Little Blue Block.*" Clay shale, roof of "*Clinton coal.*"

*This section was given in the first part of my report. It is again introduced for the purpose of showing the change of equivalent measures, in short distances.

Feet.	Inches.	Feet.	Inches.	
20	10	2	4	Coal, equivalent to coal mined at furnace.
18	6	2	6	Under clay.
16		16	0	Sandy shale. Sandstone. Locally a bed of ironstone.
18		18		Sandstone and sandy shale.
				*Coal. Clay parting. Coal. Under clay.

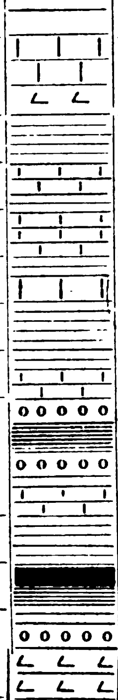
*This coal, which is found in the cistern at Clinton Furnace, is undoubtedly the equivalent of the coal with the clay parting at Star Furnace, the lower coal at Cattletsburg, the lower coal at the William's creek Tunnel, and the main Ashland coal.

No. 9. *Section on Gum branch and Straight creek, Mount Savage Iron Works, Carter county.*

Feet.	Inches.	Feet.	Inches.	
				Top of hill near iron road.
366		6		Clay on top of sandstone.
360	8	21		Heavy sandstone, equivalent of the sandstone capping sec. No. 8.
349	8	10	4	Sandstone partially exposed.
339	4	48		Covered space, shale and clay beds.
291	4	16		Argillaceous shale, highest point in the road.
275	4	8		Red band of clay, place of ore bed, on the north side of the hill.
		8		Wasted ore, yellow band of clay.
259	4	10	8	Clay. Soft sandy shale.
248	8	11	4	Red band of clay.
237	4	10		Yellow band of clay.
227	4	3		Rough, or "*blue block ore.*"
224	4	5	4	Sandstone.
219		5	4	Loose kidney ore diggings.
213	8	21	4	Covered space. Place of limestone ore ?

Feet.	Inches.	Feet.	Inches.	
192	4	11	6	Sandy shales and soft sandstone.
180	10	4	6	Bituminous shale.
176	4	5	4	Black clay.
171		32		Whitish clay. Covered space.
129		5		Red clay.
124		12		Whitish clay. Ore diggings.
112		10	8	Top of sandstone, 18 inches thick.
111	4	11	8	Top of a sandstone 20 inches thick.
99	8	5	4	Three beds of black and white clay, alternating.
94	4	10	8	Yellow sandy shale. Bed of black clay. Coal? White clay.
83	8	21	4	Sandy and clay shale.
62	4	5	4	Band of yellow clay. Band of white clay.
57		4	8	Two ledges of sandstone, 20 inches thick, over shale.
52	4	10	8	Two ledges of sandstone, 15 inches thick, over shale. Sandy shale.
41	8	26	8	Sandy shale.
15		15		Covered space.
0				Bed of branch.
20		20		Sandstone.
23		3		Grey shale.
25		2		Bituminous shale.
27		2		Coal.
29	6	2	6	Under clay.
57	6	28		Sandstone.

No. 10. *Section on Whetstone creek, on lands belonging to the Raccoon Furnace Company.*



Feet.	Inches.	Feet.	Inches.	
				Top of the hill.
244	10	10		Rough coarse sandstone, containing quartz pebbles.
				Place of limestone ore, equivalent of the *Baker bank*.
234	10	27	8	Covered space, waste of shale beds, loose ore scattered over the surface.
207	2	21	6	Covered space, sandstones partially exposed in the upper five feet.
185	8	10	8	Steep bank sandstone?
175		43	2	Steep bank sandstones, partially exposed.
131	10	21	8	Covered space.
110	2	21	8	Covered space, occasionally exposing shaley sandstone and clay shale.
88	6			Loose kidney ore, 3 to 5 inches thick.
				Clay shale.
		21	6	*Bed of ore, composed of three members.
				Sandstone and sandy shale.
67		54		Covered space, shale beds?
13		3		Coal 3 to 5 inches thick, imperfect.
				Under-clay.
10		10		Iron ore, resting on the sub-carboniferous †limestone.
				Rocks of the knobstone series.

*This bed has a block from 6 to 14 inches thick lying above a flat kidney ore from 2 to 4 inches thick, covered by a layer of kidney ore from 3 to 6 inches thick. Where this bed had been opened the layers of ore were quite regular.

†The rocks of the millstone grit series are absent.

No. 11. *Section on the northwest side of Coal creek, on the lands of the Raccoon Furnace Company.*

Feet.	Inches.	Feet.	Inches.	
				Top of hill.
299	1	59		Covered space, soft materials.
249	1	49	5	Steep bench, probably sandstone.
199	8	38		Shale and clay slate.
161	8	3		Black bituminous shale with 2 to 3 inches of coal.
158	8	86	4	Steep slope, showing sandstone ledges at several points.
72	4	10		Shale and rough thin bedded sandstone.
62	4			Place of ore bed.
		11		Cave sandstone of Coal creek.
51	4	13		Sandy shales, containing a few interrupted bands of coal.
38	4	32	4	Thin sandy shale imperfectly seen.
6		4		Bed of fire clay.
2		2		*Knob sandstone.
			0	Bed of Coal creek.

*The beds of millstone grit and sub-carboniferous limestone are absent.

No. 12. *Sections exhibiting the changes in the character of the equivalent of the ore bed principally relied upon for ores at Raccoon and Buffalo Furnaces. "Island Bank," Buffalo Furnace.*

Feet.	Inches.	Feet.	Inches.	
48	6	2	7	Top earth removed in mining.
45	11	1	2	Thin flag sandstone.
44	9	4		Argillaceous ferruginous shale.
40	9	1		Muddy sandstone.
39	9		2	Thin bed of ore, quite calcareous, containing entrochites.
39	7		3	Sandy mudstone.
39	4		4	Ore bed in blocks.
39			3	Sand bed from 2 to 4 inches thick.
38	9		9	"*Rough blue block ore.*"
38		38		Soft sandstone, thick bedded.

No. 12. (*a*) "*Dennis Sheridan's Bank,*" *formerly the Bailey Bank, Buffalo Furnace.*

Feet.	Inches.	Feet.	Inches.	
47	8	2	7	Top earth.
45	1	3		From 3 to 6 feet of argillaceous shale.
42	1		3	Kidney ore bed 3 to 6 inches.
41	10	2	9	Sandy shale.
39	1		4	Little block ore, from 3 to 5 inches thick.
38	9		9	"Blue block" apparently first quality ironstone, rejected because of its color.
38		38		Sandstone, top ledges very soft.

No. 12. (1*a*) *Moran and Crump's Bank.*

Feet.	Inches.	Feet.	Inches.	
49	6	4		Top earth removed by stripping.
45	6		6	Bed of decomposed kidney ore.
45		3		Fire clay of good quality.
42		1		Reddish argillaceous shale.
41	10		10	Muddy sandstone.
40	2	2	2	*Blocks of brown ore containing ochreous specks.
38		38		Sandstone.

*The 26 inch bed is solid, of uniform texture throughout, it separates into two unequal parts by a line parallel to neither face of the bed.

No. 12. (2*a*.) *"Buck Smith Bank," Laurel Furnace, between the main forks of Oldtown creek.*

Feet.	Inches.	Feet.	Inches.	
56	6	5		Top earth removed by stripping.
51	6	1	8	Bed of fine grained hard sandstone.
49	10	7		Fire clay with dark carbonaceous bands.
42	10		10	Kidney ore, 8 to 12 inches thick.
42			4	Block, or square kidney ore.
41	8	1	8	"Limestone" ore in two ledges containing entrochites.
40		40	?	Soft sandstone, top of mass in thick beds.

No. 12. (*b*) "*Tipton far Bank*," *Raccoon Furnace.*

Feet.	Inches.		Feet.	Inches.	
66	4		4		Top earth removed by stripping.
62	4		1		Lumpy sandstone.
61	4		4	3	Fine grained sandy shale.
57	1			1	Band of black carbonaceous matter.
57			2		Dark grey fire clay.
55			2	6	Black clay shale.
52	6		1	6	Yellowish clay with bands of a lighter color.
51	1		1	1	"*Red ore*," in two ledges.
50			50		Soft thin bedded sandstone. Heavy sandstone containing pebbles. Thiner bedded sandstone, soft.

No. 12. (1*b*) "*Kidney or Blue Block Bank*," *Raccoon Furnace.*

Feet.	Inches.		Feet.	Inches.	
64	11		4		Top earth removed by stripping.
60	11		7		Clay shale with two bands of carbonaceous matter.
53	11			5	Bed of kidney ore.
53	6		2	9	Clay shale with two black bands.
50	9			3	"Little block ore."
50	6			6	"*Red ore*," similar to the bed at Tipton bank.
50			50		Sandstone.

No. 12. (2*b*) "*Poynter Bank,*" *Raccoon Furnace.*

Feet.	Inches.	Feet.	Inches.	
61	2	4		Top earth.
57	2	2		Clay shale.
55	2	3	9	Scattered kidney ore. Clay shale with one black band of carbonaceous matter.
51	5		5	Blocks of red ore, 3 to 8 inches thick.
51		1		Blue fine grained ore, in regular bed.
50		50	?	Soft sandstone. Hard sandstone. Thin bedded sandstone.

No. 12. (3*b*) "*Company Bank, Raccoon Furnace.*

Feet.	Inches.	Feet.	Inches.	
65	6	5		Top earth.
60	6	2		Sandstone containing fossil plants.
58	6	7		Clay shale.
51	6	1	6	*Block ore, 18 inches to 2 feet thick.
50		50		Sandstone.

*Fifty yards southeastwardly of this bank, the same bed has been opened, where the ore is divided by a muddy sandstone, from 1 inch to 1 foot thick. The ores and sandstones are very unevenly bedded; the ore above and below the sandstone will average about 8 inches in thickness.

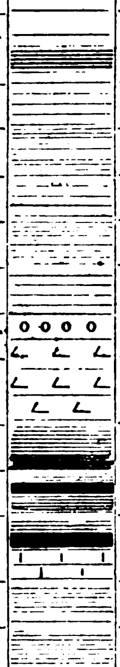
No. 13. *Section of Coal* and associate materials, on the lands of Caroline Furnace, equivalent to coal at* 220 *feet.* (*Page* 189, *report of principal Geologist for* 1856.)

Feet.	Inches.	Feet.	Inches.	
				Top of the hill.
87		10		Surface clay.
77		15		Sandstone, horizon of *pine trees*.
52		2		Black bituminous shale.
50			8	Coal.
49	4		3	Clay and shale.
49	1		10	Coal, the lower part quite slaty.
48	3		3	Under clay.
48		10		Thin bedded sandstone.
38		14		Very coarse imperfectly bedded sandstone.
24		4		†"*Limestone ore*," the upper part of the bed consists of rolled pebbles of ore imbedded in ochreous clay, lower part imperfectly stratified.
20		20		Soft sandstone and sandy shale.

*This coal is very local; it does not extend southward over one mile and a half, nor is it found extending eastwardly more than three miles; its place in the measures is indicated by dark clay deposits, frequently interrupted and often, repeated as often as 5 or 6 times in the same bed; in some localities a thin interrupted coal may be found.

†This ore is the undoubted equivalent of the Baker Bank, Laurel Furnace; Carrington Bank, Steam Furnace; "Limestone" ore of Pennsylvania Furnace; "Top hill ore" of Smith's creek; Limestone ore of Belle Fonte, &c.; further it is not the equivalent of the Limestone ores, so-called, of Kenton, Boone, and Buffalo Furnaces. The Limestone ore of Buffalo is quite local; the same geological horizon, on the lands of Buffalo Furnace, at a very short distance from the limestone ore, furnish ores without lime or containing an inconsiderable quantity of it. At no opening on the horizon of the Limestone ore of Buffalo Furnace, has ore been found (so far as I am advised) possessing the characters of the ores found at the Banks on the Buffalo Furnace lands.

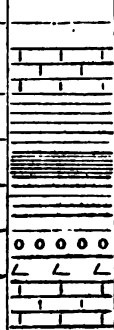
No. 14. *Section of "Limestone Ore Bank," Lanheim hollow, on the lands of the Belle Fonte Furnace Company.*



Feet.	Inches.	Feet.	Inches.	
				Top of hill.
198	10	80		Covered space.
118	10	12		Clay shale.
96	10	2	9	Surface clay removed at the bank.
94	1	4	4	Hard fine fire clay, breaking with conchoidal fracture.
89	9		7	Black clay.
89	2	3	6	Sandy argillaceous shale.
85	8		8	Limestone ore of unequal thickness.
85		5	5	Limestone, upper surface water worn and uneven; the beds lumpy; lower beds in ledges of even thickness.
80		5		Clay bed. *Locally a thin coal.
75		31		Sandy shale with bands of black clay.
44		7		Locally a thin coal, from 3 to 7 inches thick. Hearth rock beds of Belle Fonte and Clinton Furnaces.
37		22		Sandy shale.
15		15		Covered space.

*The place of the ore bed equivalent of the main beds of Buffalo and Raccoon Furnaces—see sections 12 a, and 12 b.

No. 14. (*a*) *Section of "Limestone Ore Bed," Belle Fonte Furnace, Wolf hill, west side of Hood's creek.*



Feet.	Inches.	Feet.	Inches.	
35	10	10		Hard sandstone, 10 to 15 feet thick.
25	10	7		Clay shale.
18	10		10	Black clay.
18		7		Whitish clay.
11		1		Ore bed from 12 to 15 inches thick.
10		10		Soft sandstone, 8 to 10 feet thick.
0				

*No. 14. (a1) *Section of same bed, on the opposite side of the drain, southwardly, Belle Fonte Furnace.*

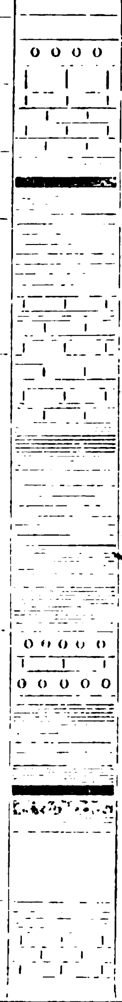
Feet.	Inches.	Feet.	Inches.	
27	10	13		Whitish clay shales.
14	10		10	Black clay shales.
14		4		Ash colored clay shale.
10		1		Black clay shale.
9		4		Whitish clay shales.
5		1		Limestone ore.
4		4		Limestone, from 4 to 5 feet thick.

*All the openings on this bed toward the south from the Lanheim hollow, except No. 14 a are covered by heavy beds of clay shale, with beds of black clay shale intercalated, varying in number from one to five.

No. 14. (*a*2) *Section of same bed,* (14*a*) *on the same hill,* 300 *yards distant south.*

Feet.	Inches.	Feet.	Inches.	
33	6	27		Alternate beds of white and black clay—there are 4 black beds each 1 foot thick.
6	6	1	6	Limestone ore.
5		5		Limestone, 4 to 5 feet thick.

No. 15. Section on Alcorn creek, near the house of Mrs. Greene.



Feet.	Inches.	Feet.	Inches.	
				Place of ore bed at 60 feet in section No. 3.
67	11	10		Sandstone, equivalent of the cave rock sandstone of Coal creek.
57	11	5		Sandy shales containing coal and pyrites in interrupted beds.
52	11	12		Sandy shale alternating with thin bands of argillaceous shale.
40	11	2	10	Shale alternating with thin beds of sandstone from 1 to 3 inches thick.
38	1	1	3	Argillaceous shale, with thin beds of sandstone intercalated from 1 to 2 inches thick.
36	10	1	10	Sandy shale containing segregated masses of sand.
35	—	8	6	Sandy shale.
26	6	3		Greyish yellow sandy shale.
23	6	3	6	Dark grey shale, sandy.
20		1	8	Bed of argillaceous shale containing several thin beds of carbonate of iron, and small rounded masses interspersed.
18	4	11		Thin beds of black shale, intercalated with beds of a lighter color.
7	4		4	Coal and black bituminous shale.
7		4		Argillaceous fire clay, resisting the action of frost and weather.
3		3		*Silicious fire clay, weathering into angular fragments. Knobstone.

*This bed of clay rests, non-conformably, on the knobstone; the millstone grit and sub carboniferous limestone are absent. One fourth of a mile down the creek a thin bed of millstone grit is seen, resting on the knobstone, wedged in between the clay and the knob sandstone. On the bed of millstone grit, the clay beds rest unconformably. The millstone grit evidently lies in a narrow trough in the knobstone, which crosses the creek from the southwest to the northeast. The surface of the disturbed beds of the millstone grit and knob sandstones having been levelled before the deposition of the clay beds, no trace of the sub-carboniferous limestone could be obtained, after the most careful and patient search.

No. 16. *Section near the limestone quarries, on the north branch of Oldtown creek.*

Feet.	Inches.	Feet.	Inches.	
42 *	1	10		Sandstone, probably the equivalent of the cave sandstone of Coal creek.
32	1	15		Shale, equivalent of the beds at 37 feet 5 inches, in section No. 15.
17	1	5		Fire clay, hard and compact breaking with concholdal fracture.
12	1		1	"*Limestone ore*," thin bed of carbonate of iron.
12		8		Sub-carboniferous limestone, the surface water-worn before the deposition of the ore.
4		4		Knobstone, 4 feet in sight.

An examination of the accompanying map of Greenup and Carter counties, will enable you to locate these sections, and to trace the gradual changes in the measures. The base of a number of the sections rest on the sandstone called in this report "*knobstone*," and the base of none of them is very far above this geological horizon, excepting section No. 9. The members of section No. 1 will be seen to contain three workable beds of ore, in the space of forty-five feet, with a space from which ore has been wrought, which, if continuous, would give four beds in 45 feet. The whole of the rocks properly included in the space from the top of the knobstone, is 213 feet, the upper hundred feet of which has not heretofore been found to contain any good beds of ore. It is composed chiefly of micacious sandstone and sandy shales. In an equivalent space in section No. 9, which is spread out and expanded to 431 feet 6 inches; and the coal measures would be still further increased at this locality if the shales and sandstones supposed to exist at the base of this section be added. The top of this section is barren of ores for 101 feet 4 inches, while the next

*This bed of sandstone is probably the equivalent of the sandstone at 60 feet in section No. 3.

space of 145 feet 8 inches affords four horizons, producing ores; in three of which the ores are worked from regular beds. The investigations at Mount Savage Furnace, did not increase the number of horizons in which regular beds of ore is found.

Section No. 3 contains 315 feet, and has six horizons in which beds of ore are found. The beds at 60 feet, 120 feet 8 inches, and at 15 feet of this section are not wrought. The bed at 120 feet 8 inches is not a workable bed at any point where it has been seen. The same remark is also true of the bed at 15 feet. The bed at 60 feet is locally a valuable ore, rising as high as 18 inches thick. The bed at the top of section, 311 feet, has not been wrought on any part of the lands of Raccoon Furnace, unless the bed about a mile from the furnace, under clay, be the equivalent of this bed. At eighty-seven feet from the base of the section at Racooon Furnace, the rock used in the construction of the stack comes in; at 120 feet, a poor ore occurs, which has not, so far as I have been able to ascertain, been worked at any locality in Greenup county. Between the last bed, and the beds here known as the company's bank and its equivalent, occurs a small coal. It is of no value, being too small for profitable working. Between the coal and the horizon of the most important ores, a heavy mass of sandstone is interstratified, nearly sixty feet thick, on top of which rests the ore worked by this company, and from which the chief part of their ores are obtained. The horizon of this bed is a few feet below the tops of the hills, and most part of the bed can be reached by stripping. It is known by a great number of names, which are generally derived from the name of the parties who first made the working upon the particular part of the bed distinguished by these names.

The ores most relied upon at Buffalo Furnace, are obtained from the equivalent of the main bed at Raccoon Furnace. It lies near the top of the hills between Clay Lick and Oldtown creek. They are certainly in the same *geological horizon* as the ores at the Raccoon Furnace ore banks, notwithstanding they differ in a remarkable manner from the ores last attended to.

All the ore beds west of Little Sandy river, from Laurel Furnace to the Ohio river, except the "*Baker bank,*" are found in section No. 3, notwithstanding the multitude of names by which they may be distinguished, and the infinite variety they present at the various points at which they have been opened in this large scope of country.

The main ridge dividing the waters of Little Sandy river and Tygert's creek, lies much nearer to the latter than the former stream. It is frequently partially interrupted by waves crossing the line of its length, thus producing several gaps.

South of the road from Greenupsburg to Liberty there is a small district capped by the limestone ore beds, equivalent to the Baker bank of Laurel Furnace; and the associated strata are found northeast of this road in all the dividing ridges, with this same limestone ore, which has been exposed by openings made in several places.

The interval of several miles southwest of the head of Alcorn creek has suffered the loss of this member, so that the tops of all the hills are capped by rocks which lie under the limestone ore bed.

It would appear that there has been a greater elevation between the heads of Coal, Whetstone, Alcorn, Clay-lick, Raccoon and Oldtown creeks than along the line of these creeks, or of those which empty into the Ohio river; swelling up the hills at the head of the branches and running in an elevated ridge, from the great dividing ridge southeastwardly toward Little Sandy. Either in consequence of denudation of the summits of the hills around Raccoon and Buffalo Furnaces, or because the elevation has taken place prior to the deposition of this bed, the limestone ore bed is here wanting. It is very probable that the strong currents of this period may have swept out this bed after it was deposited. Evidences of the devastating force of the currents of this period are manifest on the hills at the head of Alcorn creek, at the Carrington and Heighton banks at Steam Furnace, and near the office at Caroline Furnace, where the ores have been swept out and the limestone upon which it was bedded wasted and water-worn. In some places the ore is reduced to a coarse water-worn conglomerate, mixed with quartz pebbles and small rolled pieces of sandstone, giving evidence of a long continued action over a large district; where these coarse sandstones are frequently a true conglomerate, fifteen to thirty feet in thickness. This wasting did not reach the *Baker bank* at Laurel Furnace, but it extends from a point two miles east of it in a broad belt to the Ohio river opposite Ironton. If the bed was wasted after it was deposited, as I am inclined to think, some good pockets or patches of this ore bed may perhaps be found to the northwest of Little Sandy river.

Near the line of the Ohio river, where the intervals of the iron ore and coal bed spaces are contracted between sandstone ledges, no good beds of either coal or iron have been found; in fact, from the examination of the spaces which should exhibit the ore and coal beds, it is highly probable they do not exist near the Ohio below Greenupsburg. About two miles from the Ohio river, the limestone ore caps the hills on Smith's and Coal creeks, in good workable thickness, of good quality. The lowest ore bed examined at Raccoon Furnace is also a good bed of ore on both of these streams.

The horizon of the ore beds worked at Buffalo and Raccoon Furnaces, the "*Company*" and "*Island banks,*" has not yet been sufficiently examined; no openings have been made; the materials above and below this horizon are quite soft, near the place of the ore, and no section could be made of it without an opening should be made, it is therefore only known as a covered space in sections made between Raccoon creek and the Ohio.

The ore beds of Steam, Caroline and Belle Fonte Furnaces have a common character. The limestone ore bed horizon is mostly relied upon for ore stocks, but considerable quantities of ore have been obtained at Steam Furnace from the first bed lying below the limestone ore, known as the Carrington and Heighton Banks—see section No. 4. These banks affording sufficient stock of easily reducable ore, other beds have not been sought for, although they exist upon the property. The bed at 60 feet in the Raccoon section No. 3, is quite thick, on the streams emptying into Little Sandy river, west of Steam Furnace. Where this bed was opened it produced blocks about 15 inches thick, but at the locality where it was seen, it appears to contain a notable quantity of sulphur, and had been rejected at the furnace, but it does not follow that it should be elsewhere pyritiferous, especially since the same ore horizon affords ores of excellent quality at some localities.

Southwest of the strip of country before alluded to, near Laurel Furnace, the limestone ore is covered by heavy beds of clay, marking the margin of the currents from the southwest, that have wasted this ore bed. The clays of this bed, when opened, are distinguished by one or more lines of carbonaceous matter deposited in them; these black streaks are sometimes repeated four times in one section of twen-

ty-five feet in depth. The greatest depth seen, of the clay covering the limestone ore, is 27 feet, and it appears to be of still greater thickness on the lands of the Belle Fonte Furnace Company, on main Hood's creek; all the ores dug have a heavy clay covering. One mile northeast of the furnace, the same bed lies under a heavy sandstone, and the ores are mixed with sand and quartz pebbles. It is worthy of note, that as the clay covering comes in over the ore bed, the limestone beneath it disappears. I have not been able to find it outcropping south of Steam Furnace, nearer to that furnace than the Pennsylvania Furnace ore banks, where it differs materially in appearance from the same bed at Steam Furnace. In chapter 1, of my report for 1856, is a section of the limestone ore and clay, on the lands of Pennsylvania Furnace. The contrast between that section, the Baker bank, (section No. 2,) and the Carrington and Heighton bank, will illustrate the difference in physical structure of this bed. Associated with this ore bed at the Baker bank, is a thin coal, from 1 to 6 inches thick, lying below the ore bed, the ore resting upon it, with an interval of an inch of clay between them. A bed of coal is found associated with the limestone ore between Steam and Caroline Furnaces. This bed has been worked for the coal; the ore associated is in thin and in irregular patches; at present it is not worked. At the ore bank opposite Ironton is a thin coal, separated by a clay parting. This bed of coal is quite local, extending southwardly only about two miles, when the coal entirely gives out, and its horizon is represented by dark bands in the clay over the limestone ore. Eastwardly beyond Amanda Furnace, the hills are not sufficiently high (geologically,) to receive it; the high lands south of Ashland are sufficiently high, but it has not been found; its place is there filled by sandy shale and clay beds, marked by a single band of carbonaceous earth, exhibiting no coal or fossils.

An island must undoubtedly have existed during the deposition of this bed, while on the southeast the surrounding bottom subsided periodically at the rate of from one to six feet. This accumulation of carbonaceous matter was deposited during the periods of quiet, which was not of sufficient duration to produce coal on the margins around, which gradually thinned out toward water too deep for the growth of the coal producing plants. The parting of earthy matter between the coal was brought in during one of the downward movements, which has so fre-

quently marked the clay deposits south of Amanda and Belle Fonte Furnaces. Evidence of local elevations and depressions, during the deposition of all the measures above the knobstone, are to be met with at every step.

In the vicinity of Clinton Furnace, the limestone ore bed is much changed in character, and the limestone which underlies it west of Hood's creek, is entirely absent. It has not been seen at any locality east of the line of the road from Ashland to Williams' creek. The arrangement of this bed with reference to the associated materials, where it has been observed over a large district, is subject to an infinite variety of modifications. One of the most remarkable is to be seen at the Lanheim hollow, on the Belle Fonte Furnace lands, on Hood's creek. The bed of fire clay laying above the ore in that section, (sec. 14,) appears to be of most excellent quality. The clays over this ore bed, half a mile distant, do not appear to possess the qualities found in this bank.

The horizon of the hearth rocks used at Belle Fonte and Clinton Furnaces, lies about 69 or 70 feet below the ore beds at the Lanheim hollow. The section at the quarries of this rock exhibits one of the many thin non-continuous coal beds found in this part of Kentucky. The following section is made for the purpose of showing this peculiarity, as this bed extends for about two miles to the northeast, with various interruptions. It is probably the equivalent of the Belle Fonte and Clinton Furnace coals, although the connection with either of these beds has not been traced from any other locality:

Section of Hearth Rock Beds of Clinton and Belle Fonte Furnaces.

Feet.	Inches.	Feet.	Inches.	
77	8	8		Clay and shales.
69	8	50		Covered space.
19	8	1	2	Loose fine grained sandstone.
		1	6	Coarse sandstone in place.
17		5		Argillaceous shale.
12			9	*Coal.
11	3	5	4	Drab colored shale.
5	11		8	Fine grained sandstone.
5	3	1	6	Fine grained sandstone.
3	9		3	Thin sandstone.
3	6	1	6	†Hearth rock bed.
2		2		Coarse sandstone.

The limestone ore bed, in its greatest elevation on the upper branches of Hood's creek, lies from thirty to fifty feet below the highest part of the ridges, and frequently two hundred and fifty feet below the hilltops, as at Key's creek, when it is evidently in a fault or slide. At the narrows of Key's and Catlett's creek a bed of ore of recent origin has been discovered; its extent is not known. It has been opened to a thickness of four feet. The remains of the leaves of the beech (?) and a great variety of roots of recent plants and trees are found in it, generally in a state of decay. This deposit will probably be found quite local.

*The bed in the face of the quarry 75 feet long, is lost at either end of it, in a dark carbonaceous matter, between beds of drab shale.

†The hearth rock bed is of fine grained sandstone, with lines of mica about one sixteenth of an inch apart, deposited between the grains of sand composing the bed.

The coal worked at Steam Furnace has been traced by outcrop from the Furnace to Indian creek, and identified with the bed of Cannel coal on that creek.

Section of Indian creek "Cannel Coal Bank, on the lands of the Steam Furnace Company.

Feet.	Inches.		Feet.	Inches	
35	5		30		Covered space, clay and sandy shale (?)
5	5		1	6	Clay over coal, (waste of bituminous shale ?)
3	11			10	Bituminous coal.
3	1		1	8	Cannel coal.
1	5			1	Bituminous shale.
1	4	o o o o o		1	*Black band iron ore.*
1	3	o o o o o		2	*Black band iron ore.*
1	1		1		Grey clay shale.
	1			1	Bituminous coal.
					Under clay, thickness not known.

At Steam Furnace the coal has no clay parting in the opening where it was examined; in the above section which was taken two miles distant to the southeast of section (No. 15,) the whole arrangement of the bed is totally different, as well as the character of the materials. Near the place of the above section the horizon of the limestone ore bed is occupied by a thin bed of coal heretofore alluded to.

Irregularities like the above are constant throughout Greenup and Carter counties. The same beds, variously modified, are to be found on the lands of all the furnaces now in operation in Greenup, except the higher beds before alluded to in the vicinity of Caroline and Amanda Furnaces, which are not found west of Little Sandy in Greenup county. The highest measures seen in the county, are best developed, and

best seen at the old banks of Amanda Furnace, near the heads of Indian creek and Pond run.

During the present season many parts of the country that were examined last year, have been re-examined, and the opinions expressed in the report, of the progress of the work last season, have been fully confirmed. It is to be expected, from indications to the south of Greenup county, that the coal beds are increased to good workable thickness on the Big Sandy river. The uncertainty in the thickness, and irregularity of the coal beds found in Greenup county, forbids the hope of any large and profitable coal mining being carried on in the county. Coal will probably be found in sufficient abundance for the consumption of the neighborhood. The true mineral wealth of the county is its numerous and excellent beds of iron stones.

In conclusion, it is deemed proper to state, that every facility was afforded the Geological corps operating in Greenup and Carter counties, by the iron masters, and the people generally, in the prosecution of their labors, the importance of which they fully appreciated.

I would also take this occasion to bear testimony of the worth, capacity, and energy of Mr. Edward Mylotte, who conducted the field work of the eastern division. He was unfortunately drowned while the field work was being reduced. That part of the work will be somewhat delayed, but it is expected that the map will be finished by the time the Legislature meets, and in time to be engraved and distributed with the printed reports.

HANCOCK COUNTY.

During the past summer a field party has been operating in Hancock county, and the detail surveys have been carried over all that part of the county lying between the Daviess county line, and a line due south from Hawesville, to the line of Ohio county. The lines have been run with sufficient accuracy and proximity to each other to lay down the topography of all the roads, streams, principal ranges of hills, the houses of the inhabitants, out-cropping coal beds, &c., within the territory alluded to. For want of sufficient time, this field work has not been reduced and reported. All the force at my disposal has been, and is now employed on the office work of the *Eastern District*. The work in Hancock county was entrusted to Mr. Aaron Baker, and so far

as it has been carried this season, it has been under his direction. The accuracy and completeness of this work cannot be known until it shall have been reduced.

The base line from the mouth of Highland creek, which was brought during the last seasen, by Mr. Joseph R. Harris, to Hancock county, was taken up at the termination of the work of Mr. Harris, by a party under the direction of Mr. Joseph Blackwood. By an accident the instrument used by this party was so injured that it had to be sent to the maker for repairs, and the party was discharged until the repairs were made. Another party, for the work of the base line, is now organized, and the work will make such progress as the means at my disposal shall warrant. As the report to the Legislature will have gone to press before the return of this party, it cannot be reported upon in time to be embodied in the operations of the last two years.

A commencement has also been made towards the detailed examination of the geology of Hancock county, during the present summer, which, with that previously made, gives the key to all the river border of the county, from Hawesville to Lewisport.

The following addition to the published section of the coal at Hawesville, exhibits measures in the vicinity of Lewisport, in ascending order, as follows—the base of the section resting on the top coal of section No. 4, published in the report for 1854–5:

Feet.	Inches.		Feet.	Inches.	
134			20		Soft yellow sandstone, and surface earth.
114			8		Sandy shale.
106			3		Marly shale, and seggregations of limestone 3 to 5 feet thick.
103			4		Black bituminous shale.
99			4	4	Lewisport coal, (Estes' coal, &c.)
94	8		36		Covered space—soft measures.

Feet.	Inches.		Feet.	Inches.	
58	8		6		Sandy shale, under place of iron ore.
52	8		2		Sandstone.
50	8.		1		Coal.
49	8		14		Covered space, probably under clay and shale.
35	8		9		Limestone, 6 to 8 feet thick.
26	8		16		Thin sandstone and sandy shale.
10	8		4		Sandy calcareous chert beds, containing productus chonetes, entrochites, &c.
6	8		3		Cherty calcareous beds, in two well defined ledges, fossils as above.
3	8		1	7	Marly, sandy, indurated mud.
2	1			7	Very black, hard, pyritiferous limestone, with vermicular markings, containing a few productus terebratulæ, &c.—turns yellow by exposure to the atmosphere.
1	6		1	6	Argillaceous shale. Coal, top of the section of 1855–6. (See report.)

The line of outcrop on the Ohio river having been carefully traced, from the Reverday mine to Lewisport, the measures are found to dip away from the Ohio, and by faults and flexures, to sink from the hill tops at the Reverday mine to the level of the Ohio at Lead creek, where that creek emerges from the hills on the land of Mr. Adams; so that the 85 feet freestone in section No. 4, before alluded to, is found in the bed of the creek from 25 to 30 feet below high water of the Ohio. There is a reversal of dip at this point, and for a short distance the rocks dip up the Ohio river. Below Lead creek for 4 or 5 miles the country is quite level, and the river bottoms are spread out about 2 miles wide, abutting against a line of low hills, part of the dividing ridge between Lead and Yellow creeks. The hills in the rear of the river bottom are rounded, and covered by the waste of the soft materials in the upper part of section before alluded to. The dividing ridge

between the creeks is thrust forward into the bottoms of the Ohio, and terminates near the river in the bend opposite Troy. Lead creek, which held a course behind the hills parallel to the Ohio, and with the course of that stream, as soon as it passes the barrier of the hills, runs parallel to its first course, and enters the Ohio a short distance below Hawesville. On the other side of the dividing ridge Yellow creek, which had run north, as soon as it reaches the vicinity of the "bow of Lead creek," makes a right angle to its first course, and enters the Ohio above Lewisport. The dividing ridge between these creeks terminating in a bold rocky bluff, near the house of Mr. Mason, is principally composed of the heavy sandstone immediately over the Hawes' main coal, and the coal itself is brought within thirty feet of the surface at the end of the bluff. From this point the rocks dip up and down the river, and the anticlinal axis of the fold runs nearly south toward Yellow creek, for about two miles, when it curves toward the east. Between Mr. Mason's and Hawesville there are one or more minor folds, nevertheless the Hawes' *main* coal may be reached at any point along the line of the bluff and hills between Mr. Mason's and Hawesville, at distances varying from 30 to 120 feet. It is to be observed, however, that the rate of dip observed in the vicinity of Mr. Mason's, and in the Hawes' mine, that the coal would be brought up so rapidly that it is highly probable that it does not reach the river line. Between Mason's and Lewisport the same coal may be reached at proper distances from the Ohio river at various depths: as above the fold toward Hawesville, gradually sinking deeper below the surface. By the section added it will be seen that the Hawes' main coal should be 300 feet below the "Lewisport coal," or two hundred and sixty feet below the surface at the foot of the Lewisport coal mine hill, and it is doubtless much nearer the surface along the line of the railroad from the mine to Lewisport, as the rocks gradually rise in the direction of the Ohio river from the mines. The extent of the hills between Blackford and Yellow creeks forbids the idea that a very extended field of the bed, known as the Lewisport coal, especially as the limestone in the upper part of the section, on page 458-9, is generally cut in the valleys, leaving quite narrow ridges, containing this bed between them. In fact, the main Hawesville coal is brought above the drainage, about two miles northwest of Knotsville, where it is worked by Mr. Weisel. The same coal bed can be seen in out-crop at several places near Mr. Weisel's on Pup-

py creek. This bed is also opened on the northwest side of the ridge half a mile above Mr. J. V. Wathen's. The coal dips rapidly to the northwest from this last opening, bringing the coal down to the branch bottom in a short distance. On Puppy creek no complete section could be obtained, but it is evident that the sandstone covering the main Hawes' coal is much thinner here than at the Hawes' mine, or, that another limestone has been intercalated. About sixty feet above the coal, on both sides of the ridge, a limestone occurs having the general characters of the lower limestone of the section referred to above, especially in the character of the fossils contained in it.

The following section was obtained on the south side of the ridge, when the dip was to the southeast.

Section of Weisel's Coal Mines, on the head waters of Puppy creek.

Feet.	Inches.	Feet.	Inches.	
148	8			Top of hill.
		26		Covered space.
122	8	15		Sandstone.
107	8	40		Covered space.
67	8	4		Limestone.
63	8	30		Covered space.
33	8	10		Sandstone, weathering into holes.
23	8	13		Soft, yellow sandstone.
10	8	5		Sandstone, soft, of a greyish white color.
5	8		8	Bituminous shale, containing lingulæ.
5		3		Coal, the top part containing thin layers of shale.
2		2		Under clay.
			0	Bed of branch.

To the northwest in Daviess county, on the tract of land known as the Mason lands, or Spice ridge, a cannel coal was seen. This coal is certainly above the beds seen on Puppy creek, and is probably the equivalent of the shale bed into which openings have been made on the farm of Mrs. Bell, near the Yelvington and Owens boro' road. At Spice ridge the opening presents the following section:

Heighth. Ft. In.	*Thickness.* In.	
1.10	.4	Slatey cannel coal.
1.6	.7	Blackish-grey argillaceous shales.
.11	.6	Firm blocks of Cannel coal.
.5	.5	Clay shale.
.0	.0	Water line in pit.

Under the water the coal is said to be thicker than above it. By sounding the pit appears to have been sunk two feet ten inches below the water lime now in it; the soundings show fire or under clay at the bottom.

The physical appearance of the upper 4 inches is very like the coal of the Breckinridge mine. Near the spring at Mrs. Bell's farm a pit has been sunk eighteen feet deep which presents the following section:

Ft. In.	
14.0	Surface clay.
2.0	Waste of shale.
2.0	Under clay, similar to under clay of coal.

On a more elevated part of the same point a pit has been sunk into the same bed as last section above; a section of this pit is as follows:

Feet.	
15.	Surface clay.
5.	Soft sandstone.
0.	Water.

From the shales raised from below the water lime, fragments of fish were obtained, broken and scattered in the shales; no coal was seen, nor the appearance of coal. The coal has thinned out and disappeared. The distance between the Spice ridge and Mrs. Bell's is about 2 miles in a northwestwardly direction, and nearly parallel with the course of the Ohio river.

From the Hawesville mines to the locality at Mrs. Bell's there appears to be a general thinning of all the beds composing the Hawesville section. On Puppy creek the first sandstone over the Hawes' coal has diminished in thickness from 85 to 33 feet. It would be in-

teresting to science to determine this precisely. If established it would bring the Hawes' coal that much nearer the surface than it has been supposed to be, and thus make the knowledge of the position of that coal of the greatest practical value to the people of Daviess county.

With a true map of the country the determination of this, as well as other questions of the greatest importance, would be rendered simple and easy. The geological examinations should go hand in hand with the Geographical and Topographical Survey. Between Hawesville and Lewisport and the bluff above Mr. Mason's a complete section of the rocks in the bluff at the Hawes' mine can be observed. The coal under the limestone near the top of section No. 4, Report of 1855, has not improved in quality or thickness. It has been opened and exposed on the land of Mr. Curtis, near Mr. Mason's. The limestone lying 25 or 30 feet above this coal would, judging from its appearance, produce good building lime, and will be of the greatest importance as a fertilizer of the soil—occurring as it does in the immediate vicinity of a coal sufficiently good for lime burning. Lime for manuring could be produced at a very low rate. The limestone (so-called) immediately above the coal is probably too silicious to be profitably used on a sandy soil with much advantage even if burnt. The upper bed is not so generally exposed as the lower one, its place is, however, well marked, where it is not exposed, by an abrupt ascent of 25 to 30 feet in the hillside above the level the lower limestone. The value of this bed can hardly be appreciated by the farmers of Hancock county now, but the time must come when its value will be fully realized. At some localities the coal in the section at 41 feet 8 inches may be found sufficiently thick for lime burning; this coal lays 14 feet above the limestone. A more detailed examination may bring to light the extent, and the various modifications of these beds.

It may not be considered improper, before closing this report, to express my obligations to the citizens of the different counties in which it has been my duty to operate, for the hospitality and kindness extended to all engaged in the parties under my direction. The great number of persons who have rendered assistance, given valuable information, or served as guides to the best localities, forbid a separate acknowledgment for the service or kindness rendered. They have my warmest thanks.

SIDNEY S. LYON,

Assistant Geologist of Kentucky.

PALÆONTOLOGICAL REPORT

OF

SIDNEY S. LYON,

ASSISTANT GEOLOGIST.

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CHAPTER I.

PALÆONTOLOGY.

DESCRIPTION OF NEW SPECIES OF ORGANIC REMAINS.

During the progress of the Geological Survey of the State, many new and interesting fossil forms have been discovered, which, with those previously in the possession of the members of the geological corps, of new and undescribed genera and species would, were they all described and figured, make an extensive and valuable addition to the science of Palæontology. A few only of those most characteristic or remarkable, for the present publication, have been selected. They form but a small part of those deemed worthy of being carefully studied and described.

The sub-carboniferous limestone, the Coal Measures, and the transition beds of intercalated limestone near the base of the millstone grit, of western Kentucky, abounds in fossils of remarkable and beautiful forms. The living inhabitants and the dead individuals of those ancient seas, both contributed, with the wasted materials of the subjacent lands, to the formation of the sedimentary strata then in process of deposition which now serve as a guide to the student of Stratigraphical Geology, pointing out with certainty the period and geological position of rocky beds wherever found, and with great certainty indicating equivalent geological measures, which, but for these truthful histories of the past, would never be recognized as of the same age—one district presenting rocky masses, which in another are entirely changed in physical appearance and chemical composition.

In Crittenden county the sandstone of the millstone grit and associated limestones have a great thickness downward, from the productive Coal Measures, to the principal mass of the sub-carboniferous limestone on which it rests.

At the distance of two hundred feet above the base of this mass of sandstone is to be found a bed of earthy, calcareous, and shaley materials, one hundred and fifty feet thick. The lowest sixty feet of this intercalated bed, is of a drab color, filled with innumerable fragments of

Retepera Archimedes, spread out horizontally, and almost constituting the entire mass. Further from the base of the bed are found segregations, broken and irregular bands and patches of earthy ferruginous limestone. This alternation of limestones and shale beds continues to the top of the mass.

It is from the segregated masses, at the top of the first sixty feet of this intercalated calcareous bed, that some of the fossil forms selected for description were obtained; and, so far as it is at present known, certain remarkable forms of this bed have never been found extending either above or below its geological horizon.

The vertical range of the first organic form which will be described is not more than five or six feet. Two crushed specimens were found in 1845; others, again, in 1852. Having recently obtained some quite perfect specimens, it is proposed to describe them under the name of *Pentremites obesus*.

CRINOIDEA.

GENUS PENTREMITES. *Say*.

In the year 1820 the genus *Pentremites* was proposed by Mr. Thomas Say,* in which were placed certain fossil forms, then, for the first time, described. Since the erection of the genus it has been generally recognized, and many species have been added by different authors. One of the latest authorities, Messrs. De Koninck and Le Hon, state the genus under the following formula, viz:

Basal pieces,	3,	one less than the two others.
Radial pieces,	1×5,	forked, large.
Interradial,	1×5,	small lanceolate.
Pseudambulacræ,	1×5,	
Mouth,	1,	central.
Anal,	1,	lateral.
Ovarial openings,	2×5,	situated around the mouth.

By a careful examination of well preserved specimens, (not silicified,) of the different species of this genus, including the typical species, upon which the genus was founded, it may be seen that the formula above quoted should be amended. *Pentremites florealis, globosus, py-*

*See vol. ii, Silliman's Journal, p. 36, and American Journal of Science and Arts, vol. 2.

riformis, and others, have severally three small plates or pieces, distinctly separated from the pieces heretofore designated as the "*Basal pieces;*" these three pieces form the base of the cup, and as they lie below the pieces heretofore recognized as basal, are true basal pieces, and the others necessarily become first radials. It is therefore proposed to amend the generic description, and the following formula is offered:

GENUS PENTREMITES. *Say.*

Generic Formula:

Basal pieces,	1×3,	short, broad, and nearly of equal size.
First radial pieces,	1×3,	two hexagonal, perfect; one pentagonal, and imperfect.
Second radial pecies,	1×5,	nearly of equal size, long, forked.
Interradial pieces,	1×5,	small, lanceolate, nearly equal in size.
Pseudambulacræ,	1×5,	long, filling the forked pieces, and terminating around the mouth.
Mouth,	1,	central.
Ovarial openings,	2×5,	situated around the mouth.

Column, cylindrical, perforated, segments luaeq size and thickness.
equal

PENTREMITES OBESUS. *Lyon.*

(Plate II. fig. I, 1 *a*, 1 *b*, 1 *c*, 1 *d*.)

Body, elliptical half its heighth, rounded at the summit; the lower part has the form of a broad inverted cone; the diameter is to the heighth as 4 is to 5, (nearly.) *Basal pieces*, of equal size, sub-quadrangular, of similar form, low, broad; sides diverging upwards from the columnar articulation; greatest heighth at the line of junction with each other; irregularly concave, upper margin, into which the first radials are fitted, regularly concave at their junction with the column; when joined, they form a low cup, concave at the base, the upper margin forming an unequal sided triangle.

First radials two, of equal size, hexagonal; the third pentagonal, and a little larger than half the size of the hexagonal pieces; this unequal piece probably indicates the anal side of the pentremite; the three pieces, when joined, present a broad shallow cup, the superior margin of which is marked by five broad angular points, between which are three angular, and two irregular, concave depressions, the latter being upon the summits of the hexagonal pieces.

Second radials five, divided two-thirds their length, swelling rapidly from their junction with the first radials to the inferior end of the pseudambulacral fields; twice as long as wide, the branches increasing in width from their junction with the interradials toward the base; obliquely truncated above, the truncation being by a sigmoid line, (not straight as is usually the case,) meeting and fitting upon the interradials by a lap, being beveled from within, the beveled surface being about three times as long as the thickness of the pieces; abutting squarely at their lateral margins against each other, two resting upon the complete hexagonal fist radials, and the other three resting upon the beveled sides and in the notches formed by the junction of the first radials; the line of junction of the sides occupies the center of a deep elliptical grove.

Interradial pieces five, half as broad as long, (externally;) angularly pointed above, and roundly pointed below; $\frac{1}{4}$ as long as the second radials; within the body they are prolonged, and extended under the second radials, and terminate in a long point on either side, forming part of the wall of the pseudambulacral areas; the centre is also extended downwards and pointed, laping under the suture, marking the junction of the second radial pieces.

The interradials are marked by fine striæ, (lines of increment,) which conform to the external form of the piece in its different stages of growth.

The first and second radials are also marked by lines of increment. In the first radials the lines conform to the sides and upper margins of the pieces; the second radials are marked with lines extending entirely around them, except around the margin of the fork, into which are inserted the pseudambulacral fields. All the pieces are divested of the epidermis and muscular coat. The true external markings are unknown.

Pseudambulacral areas extend from the mouth, at the centre of the summit, a little below the centre of the length of the body, gradually increasing in width by a curved line on either side from below upwards, to the centre, when they diminish in width until they reach the summit, they are composed of a double row of thin plates, about twelve times as long as thick, about as broad as long, joined together by their broad faces, terminating at the centre margin of the field, at a

foramen which divides these pieces; the divided sides of the foramen pieces diverge slightly, and join a similar diverging side from an adjoining foramen piece, with which it unites and forms a ridge, which continues to the margin of the field to which they are joined. The field is divided longitudinally in the centre, by a deep groove, the foramen pieces are marked by a slight groove, which crosses them near the centre of their length, and runs the whole length, dividing the field into four bands. Where the foramen pieces are crossed by this slight groove, they are frequently indented by a furrow, which sometimes continues the whole length of the pieces; it is frequently nearly obliterated, and then presents a rounded, oval, or lozenge shaped dent or hole. These marks have the appearance of the imperfectly closed sides of two pieces having grown together. At one state of their growth they were, probably, in separate pieces. In the best preserved specimens the broad faces are seen to be furrowed or grooved transversely; the ends of these grooves are seen presenting small punctures, while the sides of the grooves present a double row of little knobs, standing opposite each other, and joining the two adjacent pieces, which touch each other at these ridges. The ends of the foramen pieces abutting against the centre furrow of the field, are flattened and rounded, the rounding on the inferior side of the piece being greatest. The flattened ends are ornamented by eight or ten diverging ribs, forming on the ends of the pieces a series of beautiful fan-like ornaments, each slightly concave. The foramen pieces number from sixty to seventy to the inch—one specimen having one hundred and fifty on each side of the field; another (young,) having only forty-three, or eighty-six in each pseudambulacral space.

Mouth. The mouth is irregularly rounded, small externally, increasing in size as the opening passes downward into the body; it is formed of five pieces, lying immediately within the ovarial openings; it was, doubtless, capable of being opened and largely expanded, by the opening of the five petal-like parts into which the body is divided. There is a deep indentation opposite to, and lying between, the lower ends of the pseudambulacral fields; this indentation probably marks the limit of the flexibility of the petals.

Ovarial openings five, nearly round; one much larger than the others; the large opening on the point nearly opposite the imperfect

first radial. *Column* cylindrical, formed of pieces of equal thickness, articulating by radiated surfaces, the rays covering the entire surface; perforated; opening small; pentelobate; side arms at irregular intervals, frequently opposite each other, formed of similar pieces to the column.

This species differs from all others heretofore described, being much larger; the whole character is coarse and strong; the pieces are remarkably thick—in the young, of a similar sized specimen, being twice the thickness of any known species. The general form is nearest that of *P. floreales*. *Say*.

Length of specimen under description, - -	$2.\frac{35}{100}$ inches.
Breadth of specimen under description, - -	$2.\frac{05}{100}$ inches.
Vertical circumference, - - - -	$6.\frac{15}{100}$ inches.
Transverse circumference, - - - -	$6.\frac{00}{000}$ inches.

In the largest specimen observed, the pseudambulacral field is $1.\frac{95}{100}$ inches; that of our specimen is $1.\frac{75}{100}$ inches; length of smallest specimen, one inch; the field of this specimen is $\frac{50}{100}$, (half an inch.)

The pieces forming the pseudambulacral areas, are thiner than those of the *globosus* or *pyriformis*, (small species.)

GENUS ASTEROCRINUS. *Lyon.*

Gen. char.—*Column*, cylindrical, perforated; base, bilobate; primary radials five; secondary radials, first series, ten; second series, twenty; lobe pieces, five; arms twenty, formed of a double row of joints.

ASTEROCRINUS CAPITALIS. *Lyon.*

(Plate III. fig. 1, 1*a*, 1*b*, 1*c*, 1*d*, 1*e*, 1*f*, 1*g*, 1*h*, 1*i*, 1*k*.)

Specific description.—*Body*, viewed from above, presents somewhat the form of an irregular five-pointed star*; viewed in profile, erect, it has much the form of a corinthian capital, slightly contracted near its base.

Column, cylindrical, composed of numerous, unequal-sized, thin, circular pieces. The articulating facets are striated around their margins—the elevated ridges of one joint fitting into corresponding depressions in those which adjoin it. At a short distance from the body these pieces are arranged into the column in sets of three, between two

*The specimen figured, is slightly crushed, therefore the star-like figure is not so remarkable.

quite thick pieces, those adjoining the thick pieces are quite thin, with one much thicker between; nearer the body the pieces are alternately larger and smaller; their edges are slightly rounded.

Basal pieces, two of equal size, nearly alike; united they form a shallow elliptical cup, the upper margin being indented by four concave and two angular notches, swelling below the margin of the cup. The inferior surface presents an imperfect elliptical depression, in the centre of which lies a deep circular pit, concave at the bottom; the outer margin of which is marked around its circumference by grooves and ridges, by which it is joined to the column.

Primary radials five, differing in form; the piece opposite the anal side is slightly concave on the upper margin; the ends are nearly parallel to each other; twice as broad as high; the inferior margin is angularly pointed—the point being about the centre of the width of the piece, at which point it is twice as high as at the ends. The four other primary radials are convex below, and fit into the concave indentations of the basal pieces; they are low and broad; not quite as high as the first pieces; two are concave above, the lower and upper margins being nearly parallel; the other two have two concave depressions above, of unequal size; the ends of the four pieces are obliquely diverging from below upwards—the ends joining the anal piece having the greatest divergency.

Secondary radials. These are in two series, the first consisting of ten pieces, no two of which are alike; those resting on the first radial opposite the anal side are convex below; as broad as high, the upper margin of each having two concave indentations; the junction of these pieces with each other is square, the opposite ends terminating in an angular point. The secondary radial pieces resting upon the first radial piece, to the right of the anal piece, are terminated at both ends by angular points; from one of these rise three secondary radials of the second series; from the other, only one.

The next secondary radials to the right are, probably, broken, and in our specimen are represented by four quadrangular pieces of unequal size. The other four pieces are nearly of equal size, sub-quadrangular; twice as broad as high, having two concave notches in the upper margin of each.

Secondary radials. The secondary radials are twenty in number;

nearly equal in size; sub-quadrangular; as broad as high. From each of these the arm takes its origin.

Anal piece. Lozenge shaped; small; rising from the smallest angular depression in the basal pieces.

Lobe pieces. These remarkable appendages are five in number; unequal in size; thick, rounded, and club-like; twice as broad as thick at the superior extremity, tapering downward, and ending in a broad fan-like manner, at the inferior extremity. They are divided into three unequal parts, the union of the parts being marked by sutures; the upper part not unlike a seed vessel, (when first discovered by the country-people these parts were supposed to be petrified seeds, and were called "petrified coffee-nuts;") it is more than one-third the length of the whole lobe piece; with the middle piece it makes two-thirds the length; the lower part is irregularly serrated, and marked by the impression of muscular attachments; it fits into and is attached to the inside of the basal pieces.

Arms. Our species has twenty arms, in sets of four, rising from the second series of secondary radials; they are composed of a double series of joints, beautifully articulating with each other—the salient angles of one set filling the re-entering angles of the adjoining set; the arms are regularly tapering from their insertion to the end, where they terminate in a point, rising about one-fourth their length above the highest point of the lobe pieces; each set is separated into pairs by the lobe pieces, which embrace them on either side. It is not certainly known that the arms are provided with cillia.

This remarkable crinoid is found in the lower intercalated calcareous beds of the millstone grit of Crittenden county, associated with *Pentremites obesus, &c.* The vertical range of this species is somewhat greater than that of that fossil. It was very abundant; immense numbers of the fragments of the lobed pieces are found, especially of that part forming its upper extremity. It is evident that they were easily separated, for amongst the multitude of fragments only one specimen has been found sufficiently perfect to show the arrangement of the parts composing it; this is slightly flattened by pressure, and is so much weathered that no surface markings can be discovered. By the fragments of the lobe pieces the lower intercalated limestone of the millstone grit may be identified.

Its proportions are as follows:

Heighth, - - - - - - -	1.$\frac{25}{100}$ inches.
Greatest breadth across the lobe pieces, -	1.$\frac{55}{100}$ inches.
Greatest breadth at the top of calyx—narrow side, - - - - - - -	.$\frac{75}{100}$ inch.
Greatest breadth at the top of calyx—wide side, - - - - - - -	.$\frac{85}{100}$ inch.
Heighth of calyx, - - - - - -	.$\frac{40}{100}$ inch.
Heighth of radials, - - - - - -	.$\frac{15}{100}$ inch.
Heighth of basal pieces, - - - - -	.$\frac{25}{100}$ inch.
Long diameter of basal pieces, - - - -	.$\frac{60}{100}$ inch.
Short diameter of basal pieces, - - - -	.$\frac{40}{100}$ inch.

The genus *Asterocrinus*, by its lobed basal pieces, is allied to *Dichocrinus*, also by the number of its primary radials Here the analogy ceases. *Dichocrinus* partakes much of the character of the *Platycrinites*. The primary radials are generally longer, and the calyx high; the radials of all known species of *Dichocrinus* are higher than the basal pieces, while in *Asterocrinus* the breadth of the radials are equal to twice their hight. In the remarkable lobe pieces it is distinguished and separated from all known genera. It is evident the species under consideration had no vaulted covering to the stomach, as the lobe pieces rise from the basal pieces, (to which they are attached,) and nearly fill the cavity of the body. The lobe pieces are free, except at the point of attachment at the base, were expansile, and are indeed auxiliaries of the arms, probably serving in part to sieze and crush its food. Fixed to the base by a muscular ligament, articulating by joints, they were evidently capable of opening with, or even independently of the arms. Our specimen is closed; the arms are folded between the lobe pieces. Six half sets of the arms have their entire length, and are folded toward the centre of the summit, which they do not reach, leaving the junctures of the lobe pieces exposed.

In a paper read before the Academy of Sciences, at St. Louis, Missouri, in 1857, our specimen is referred to, and classed with *Dichocrinus;* we differ from the author of that paper, and hold that our species is essentially different, and should be separated from *Dichocrinus*.

ASTEROCRINUS (?) CORONARIUS. *Lyon.*

(Plate I. fig. 1, 1 a.)

It is with a considerable hesitation that this remarkable and hitherto unknown fossil is refered to *Asterocrinus*, as it has neither basal, radial, or arm pieces. This unique crinoidal fragment was found, with others, associated with *Pentremites obesus*, *Asterocrinus capitalis*, &c., in the lower intercalated calcareous bed of the millstone grit of Crittenden county. This specimen is evidently the summit and part of the abdominal cavity and walls of a crinoid, and is provisionally referred to *Asterocrinus*, which it greatly resembles, by the arrangement of the tumid star-like points; seen in profile it resembles a ducal coronet or crown. The body is pentagonal, having equal sides; the angular corners are removed; an angular notch is provided, into which three of the point pieces are inserted into the body. The point on the right of the oral opening is joined to the body by an irregular line, nearly straight; that on the left is joined by a curved line, with an angular deflection near the side farthest from the mouth. The marginal borders of the pointed pieces are raised, and the pieces are fluted about two-thirds their length; they are thick, heavy, and solid; curved on the lower side, and when resting upon the upper surface, present the appearance of a thick last, from the instep to the toe. Within the pointed pieces are arranged twenty-five polygonal pieces—those immediately surrounding the mouth are convex, the others are concave; the outer series are larger; two are hexagonal; the others are imperfect rhombs; those within the point to the right of the mouth are small and long; the others are still smaller, of pentagonal, hexagonal, and triangular forms. A few of the small pieces surrounding the oral opening have been lost.

Mouth, sub-central.

Lower surface. Between the pointed pieces are three angular prominences, and four angular depressions; these are probably the articulating surfaces to which the lower part of the body and calyx were joined; above these notches and prominences, and on the surface between the pointed pieces are rounded and grooved impressions, probably produced by the pressure of the arms (?) No surface markings are found on the specimen, which has evidently lost its dermal covering; they would have been lost had they existed upon it.

Size of the specimen. Length of the pointed pieces, (the longest piece,) - - - - - - - - - $.\frac{70}{100}$ inch.

Length of the pointed pieces, (shortest piece,) -	$.\frac{55}{100}$ inch.
Longest diameter across the points, - -	$1.\frac{95}{100}$ inches.
Longest diameter of body, upper side, - -	$.\frac{75}{100}$ inch.
Longest diameter of body, lower side, - -	$.\frac{80}{100}$ inch.
Height of body to junction of pointed pieces, -	$.\frac{55}{100}$ inch.
Height of body to highest point of pointed pieces,	$.\frac{75}{100}$ inch.
From mouth to nearest side, - - - -	$.\frac{30}{100}$ inch.
From mouth to most distant side, - - -	$.\frac{50}{100}$ inch.

GENUS GRAPHIOCRINUS. *DeKoninck and LeHon.*

De Koninck and LeHon, who established this genus, have given the generic formula as follows, viz :

*Basal pieces,	5.
Radial pieces,	2×5.
Anal pieces,	1.
Interradial pieces,	0.
Arms,	10, not divided.

GRAPHIOCRINUS—14 BRACHIALIS. *Lyon.*

(Plate I. fig. 1, 2 *a*, 2*b*.)

The anatomical structure of our species corresponds so nearly to this genus that it is confidently referred to it.

Column. A short piece of the column, still attached to our specimen, is composed of thin circular pieces, rounded on the margin, differing considerably in size—alternately a larger and smaller one; perforated; the form of the perforation cannot be distinctly made out.

Basal pieces five; long lanceolate; thick at the outer point; divided by deep well defined sutures, from the inferior point of the primary radials, to the opening of the columnar-pit, where the pieces join evenly together; the superior points curved upwards, from the columns outward; the pieces are grooved by a broad concave furrrow, which termi-

*From the figure given by De Koninck and LeHon, I have much doubt if these are the true basal pieces. Species of kindred form are found with fine basal pieces within the columnar depression; these are generally covered by the column; always alternating with the basal pieces, as recognised in the above formula. There are another class of crinoids having a pentagonal basal piece, not indented, divided by five sutures running from the columnar pit to the centre of the sides, forming the pentagon. *Zeacrinites Magnoliaformis—Troost*, is thus distinguished.

nates at the commencement of the upward curvature of the points of the pieces. The piece to the right of the anal pieces is larger than the others, and the first primary radial rises from its truncated point; in this respect the drawing is imperfect—the side toward the anal pieces should be more elevated. The surface of all the pieces is smooth.

Primary radials five; somewhat heart-shaped; concave above, roundly pointed below; the pieces on either side of the anal pieces are not symetrical—the side of the left hand one having lost a portion of its edge, against which rests one of the anal pieces, while that on the right side has lost a portion of its inferior left margin, which joins the largest anal piece.

The primary radials of the second series* are five in number; subquadrangular; width, equal twice the greatest heighth; differing in form and size; sides square and vertical; swelling rapidly from the sides toward the center; curved upwards on the superior margin, and terminating in a rounded prominent knob, at or near the center of the pieces.

Secondary radials (*axilary, Miller,*) ten; four are larger than the others; similar in form to the primary radials of the first series inverted; boldly prominent, each supporting two secondary radials of the second series; the six others differ in form, and are less than half the size of the first four, each supporting a single piece of the secondary radials; slightly prominent.

Secondary radials, second series, consists of fourteen subquadrangular pieces, differing slightly in size; less prominent than the first series, from which the arms take their origin.

Arms fourteen, composed of a double row of pieces, slightly rounded, fitting deeply into each other—the salient angles of the right hand row entering the retreating angles of the opposite row.

Remarks.—Our specimen has been slightly crushed; the superior ends of the arms are broken off; the calyx is remarkable for the depth of the columnar depression, and the prominence of the rounded knobed terminations of the pieces forming it, also, in having fourteen arms—the typical form of the genus having only ten. It was found in the calcareous beds, near the base of the millstone grit of Crittenden coun-

* The primary radials of the second series are here equivalent to the scapular pieces of Miller, corresponding to the scapular pieces of *Encrinites moniliformis.*

ty, associated with *P. obesus*, *Asterocrinus capitalis*, *A. coronarius*, &c. Ranging rather higher in the bed than either of the others. The vertical range is not known. It has not, so far as we are informed, been discovered in any other geological horizon.

ACTINOCRINUS. *Miller.*

This genus was established by Miller in 1821, and was defined as follows:

"A crinoid animal, with a round column, perforated by a round alimentary canal. At the summit of the column is placed a pelvis, formed of three plates, on which five costals, and one irregular, adhere; which are succeeded by the second costals and intercostals, and the scapulae, from whence five arms proceed, forming two hands, with several tentaculated fingers.

Round side-arms proceed at irregular distances from the column, which terminates at the base in a fassicular bundle or roots of fibres."

Recently De Koninck and De Hon, in treating of this genus, have adopted a different nomenclature. The *Actinocrinus*, as defined by these authors, is as follows:

Generic Formula:

Basal pieces,	3, of a quadrangular form.
Radial pieces,	3×5.
Interradial pieces,	3×4.
Anal pieces,	6.
Brachial pieces,	1, or 2×5.

Column, cylindrical; canal, pentagonal.

ACTINOCRINUS ABNORMIS. *Lyon.*

(Plate IV. fig. 1, 1*a*, 1*b*.)

Body. The general form of the most symetrical of this species is sub-globular; others are quite shallow; saucer shaped; with a very low, irregular; covering in others the circle of the body, at the insertion of the arms, is deeply emarginate. The form of the inferior part of the calyx is constantly that of a shallow rounded cup, slightly indented around the columnar pit. The basal pieces, and the radials of the 1st and 2nd series, are also constant characteristics.

The superior surface has a continuous covering, composed of small pieces; the spaces opposite the junction of the arms with the body have

generally prominent tubercles, usually rounded and low, sometimes long and sharp-pointed; an additional knob or point usually marks the summit, which is sub-central and near the anal side; around these prominent pieces, are arranged, in a circular manner, small polygonal pieces of various sizes, and the interspaces between these circular patches are filled with pieces of irregular forms; in some of the best preserved several knobs are joined by the interspace, having a central piece, around which are arranged, circularly, small pieces—one piece of the circle forming the connection between the centers of the adjoining circles.

Our description is that of a single specimen, differing in many particulars from all others of the species; yet it is believed that no accurate observer could fail to roorganize every specimen of the species, by features they have in common, which distinguishes them from other species.

Basal pieces. The basal pieces, when undivided, presents an oblong hexagonal space—the middle perforation being sub-central; when divided, the sutures from the central opening terminate at the center of the inferior margin of the alternate radial pieces of the first series; by this division producing two pieces nearly equal in size, and one generally smaller than the others.

Radial pieces, 1st series. Consists of six hexagonal pieces, (one of these pieces is sometimes pentagonal or obscurely hexagonal,) differing somewhat in size and form; slightly concave—the concavity extending over the whole area of each piece; when arranged in the cup they are nearly horizontal, being only slightly curved.

Primary radials, 2nd series, five; usually four hexagonal and one pentagonal; not unfrequently one of the radials is abnormal, and rises between two of the radials of the first series. Fig. 1b, plate IV, exhibits this anomalous arrangement. Fig. 1a, plate IV, shows all the pieces in a normal condition (hexagonal.)

The 3rd series of primary radials consist of four pieces septilateral, and one hexagonal; nearly equal in size.

Secondary radials, 1st series, consists of eleven pieces, varying in size and form—some being heptagonal, hexagonal, and one being pentagonal; this last piece rises from the anomalous ray. (Fig. 1b, plate IV.)

Interradial fields. The interradial fields are four in number, each filled with six pieces, differing in form and size; arranged by one forming the base; from the sloping upper sides of this rise two others; between these latter and their outer upper side, three others; upon these rest the interaxilary pieces, eleven in number; these vary much in form and size in different specimens.

Nearly all the pieces composing the 2nd and 3rd primary radials, and the interradial fields are flattened or slightly concave; this is characteristic and common to the species.

Anal pieces. The anal pieces vary much in different specimens—from 14 to 18 of irregular form; being neither constant in form nor number.

The *Arms* vary in number from ten to fourteen, at their insertion into the calyx; they are very irregular in their arrangement, sometimes coming off in five regular pairs; again three pairs—one set of three, and one set of one, making ten; again, three sets of four each, one set of three, one of two, and a single arm, standing by itself, making fourteen.

Amongst the great number of the species that have come under our observation, no two have ever been observed with precisely the same arrangement in the zone forming the region of the arms—sufficient difference frequently existing, in different specimens, to warrant a separation of the species if the technical arrangement should be relied upon. By the low calyx, concave surface of the pieces, and general appearance, they will, however, be referred o1ɔ species.

Dimensions:

Greatest heighth of calyx, - - - -	$.\frac{65}{100}$ inch.
Least heighth of calyx, - - - - -	$.\frac{30}{100}$ inch.
Heigth from base to summit, - - - -	$.\frac{90}{100}$ inch.
Greatest breadth, - - - - - -	$1.\frac{50}{100}$ inches.
Least breadth, - - - - - -	$1.\frac{30}{100}$ inches.

Position and locality. Very abundant in the limestone immediately at the base of the "Devonian black slate," and above the beds of Hydraulic cement stone. In the vicinity of Louisville, about fifty feet above the range of *Catenepora escharoides* bed. *Actinocrinus abnormis* is especially abundant in the bed above alluded to, exposed at the quarries, on the south fork of Bear grass creek; at Rock Island, near

the old Tariscon's mill, at the foot of the falls of the Ohio; and at the crossing of the Jeffersonville and Columbus railroad, on Silver creek, Clarke county, Ia. It has not been found extending beyond this bed—which varies in thickness from five to twelve or thirteen feet. Of the numerous specimens obtained by collectors, most of them are mere fragments; very few have more than half or three-fourths of the head complete—many not so much. This is the most abundant fossil form of the bed at the locality on Beargrass.

GENUS DOLATOCRINUS. *Lyon.*

Gen. char.—*Column*, round; composed (near the body) of alternate large and small pieces; perforation pentalobate; rather large; basal pieces five; pentagonal; small; sometimes covered by the column.

First radials five, hexagonal; *second radials* five, quadrangular; *third radials* five, pentagonal; *first secondary radials*, ten or eleven, generally hexagonal; *second secondary radials* quite irregular, varying from ten to thirteen; *interaxilarys*, those rising from the radials from five to seven, whilst those which rise from the interradial fields vary from ten to twelve; *interradials*, *first series*, five, large nonagonal; the *second series*, of five, differing in form; *arms* ten, formed of circular pieces of equal thickness, tapering rapidly toward the superior end; *mouth* sub-central proboscidate; *summit* covered by small polygonal pieces.

DOLATOCRINUS LACUS. *Lyon.*

Plate IV. fig. 2, 2*a*, 2*b*, 2*c*.

Specific character.—*Body* sub-globose; truncated below; columnar-pit broad and deep; summit somewhat conical, prolonged by a proboscis; column round; near the body composed of alternate large and smaller pieces articulating by flat radiated surfaces; the upper joint of the column is hemispherical, and partially fills the columnar-pit, nearly and sometimes quite concealing the basal pieces; columnar perforation rather large and pentalobate.

Basal pieces five;* pentagonal; nearly of equal size; not quite as

*The basal pieces are only seen in fragments and crushed specimens; from these we are led to believe that the basal pieces are five in number; should future investigation determine that the base is divided into only three parts, the base would then resemble that of *Platycrinus*, *Miller*, not *Austin* Being now fully pursuaded that this arrangement of five basals, alternating with five first radials, is the structure of the animal, we have so described it.

high as wide; lying deep in the columnar-pit, and frequently concealed by the insertion of the columns, as in fig. 2c, plate IV.

First radial pieces five; hexagonal; nearly equal in size; twice as broad as high; ornamented by sculptured ridges, which terminate at a longish or rounded knob, near the margin of the columnar depression.

Second radial pieces five; sub-quadrangular; wider than high; nearly of the same size; the center of the pieces are ornamented by a knob, which terminates at this upper margin. In specimens of the aged of this species the knob is frequently prolonged, and assumes the form of a sharp ridge.

Third radials five; pentagonal; broader than high; same size, ornamented near their center by a knob.

Secondary radials, first series ten of irregular form; as large as or larger than the third primary radials; principally hexagonal—sometimes one or more are pentagonal.

Secondary radials, second series, varying in number from ten to thirteen; irregular in form and size. *Interaxilary pieces*; these pieces are variable, differing in form and size, and are distinguished as triangular and quadrangular—the triangular pieces having their origin in the radial pieces; eight in number; those originating from the interradial piece of the second series are quadrangular; twelve or more in number.

Interradials five; very large; nonagonal; angularly pointed below; truncated on the superior margin; from these rise the secondary radials, five in number, four of which are pentagonal; pointed at the summit; inferior margin as wide as the superior margin of the first interradials on which they rest; the other piece is quadrangular.

The *arms* are ten in number, rising in pairs; rather short; tapering rapidly; composed of ovoid flat pieces, of equal thickness—one side exhibiting the articulating surfaces from which tentaculæ have been detached; the form and arrangement of the tentaculæ are unknown.

Summit. The summit is covered by rather large polygonal pieces, various in form; generally ornamented by small granular prominences.

Proboscis or oral tube. In its complete form it is unknown; judging from the fragments found attached to the specimens, it is small compared with the same appendage in other crinoids; composed of small polygonal pieces.

External markings. The body is adorned by a most beautiful network of raised triangular figures; the points of the principal triangular figures rise from, and terminate at, the centre of the first interradial pieces; a subordinate set of figures terminate at the centre of all the pieces below the arms. In some specimens the lines are continuous, in others, interrupted. The summit pieces are sometimes adorned by a single prominent granule; in other specimens, many of the pieces are ornamented by a number of granules, arranged in lines across some of the pieces in nearly parallel rows, or in a circular band around a more prominent central one.

Geological position and locality. Found in great numbers in the limestone immediately over the hydraulic cement beds, Jefferson county, Kentucky, on Beargrass creek; same beds on Rock Island, Falls of the Ohio river, and Silver creek, Clarke county, Indiana.

In the neighborhood of Louisville, resting on the hydraulic cement bed, and below the black slate of the Denovian period, occurs a thin bed of limestone, its base resting on the cement stone bed; in this is to be found a partial bed of conglomerate, of ferruginous gravel; a similar bed of conglomerate exists below the cement bed. The cement bed at Beargrass creek is from four to six inches thick. Northwsetwaardly, three and a half miles, at the foot of the Falls, on the Indiana side of the river, this stone is eighteen feet thick; from the bed, at the foot of the Falls, large quantities of hydraulic cement is manufactured, of superior quality. Resting on the cement bed, as before stated, is a bed of limestone from four to eight feet thick; the inferior two feet abounds in *crinoidæ*, in fact, the bed is literally made up of the remains of these animals. Then succeeds, about two feet abounding in *fossil corals*, amongst which are a few *entrochites;* these are again succeeded by *Crenoidea, Brachiopoda, and Trilobites.* Upon the whole rests a bed of black slate, variously estimated from one hundred to one hundred and forty feet thick.

A few individuals of our genus, and probably of the same species, occur at the base of the hydraulic beds; these are seldom well preserved; should these prove to be our species, the vertical range of the species will be about twenty-five feet; should they prove to be different, the range will be only about two and a half or three feet.

GENUS VASOCRINUS. *Lyon.*

Gen. char.—*Body* vase shaped; twice as wide as high; *basal pieces* five; pentagonal; pointed at their superior margin; *primary radials* five; rising between the points of the basal pieces; *secondary radials* five; broad; irregularly pentagonal; *arms* five; single; composed of cylindrical pieces; *anal piece* one; hexagonal; large; summit unknown; *column* unknown.

VASOCRINUS VALENS. *Lyon.*

(Plate IV. fig. 3, 3 *a*.)

Basal pieces five; low, broad; pointed at their summit; swelling at the base; forming a shallow cup, with perpendicular sides; bottom slightly concave; superior margin divided by obtuse points into five broad, shallow, angular notches; the base articulates with the column by a surface marked by striæ, radiating from a small circular opening.

Radial pieces five; smooth; sub-hexagonal; differing slightly in size; higher than wide; rising between the basal pieces.

Secondary radials five in number; smooth; pentagonal; nearly twice as wide as high; the median line of these pieces are nearly horizontal; the truncated face, for the insertion of the arms, eliptical, concave, perforated near the centre, deeply sulcate above the perforation; the sides are joined together, curving upward and terminating on the summit between the arms; the piece on the left of the anal piece is much larger than either of the others, and covers the points of two of the radials, whilst that on the right of it is much smaller than the others, and rises from the point and left side of the primary radial, beneath it. The *anal piece* is large, sub-hexagonal, rising between two of the primary radials, and extends above the lower margin of the axillary face of the second primary radials.

Arms composed of cylindrical pieces, their legnth and diameter being nearly equal; perforated and deeply sulcate on the superior side.

Dimensions:

Diameter of the base, - - - - -	$.\frac{45}{100}$ inch.
Height of the base, - - - - - -	$.\frac{27}{100}$ inch.
Height of the body, - - - - - -	$.\frac{55}{100}$ inch.
Greatest diameter, - - - - - -	$1.\frac{05}{100}$ inches.
Diameter of the axillary articulation, - -	$.\frac{27}{100}$ inch.

Remarks. This remarkable crinoid was obtained several years since at the quarries on Beargrass creek, near Louisville, where it was found associated with *Actinocrinus*. *Dolatocrinus*, &c. It is very rare—this specimen is the only one of this species heretofore obtained.

VASOCRINUS SCULPTUS. *Lyon.*

(Plate IV. fig. 3*b*, 3*c*, 3*d*, 3*e*.)

Body small; vase shaped; section at the junction of the arms pentagonal; side of pentagon above the anal pieces nearly twice as long as either of the others; the surface is roughened by raised sculpture; the center of the pieces below the arms are all prominent. On either side of the sutures marking the junction of the basal pieces is a raised rib, which terminates at the center of the first radial pieces lying above the sutures. Similar ribs cover the body, extending from near the center of each to the center of all the contiguous pieces, (except the basal pieces,) thus dividing the surface into nearly equal-sided triangular spaces, deeply depressed at the center, and curving up to the ribs which define them; at the end of the ribs the triangular spaces are joined by a narrow grooved avenue, not quite so deep as the center of the spaces.

Basal pieces five; pentagonal; as high as wide; extending beneath to the columnar perforation; junction with the column slightly concave.

Radial pieces five; hexagonal; four of equal size; as high as wide; one much larger than the others, rising between the points of the basal pieces.

Secondary radials (*scapulæ*, *Miller*) five; irregularly pentagonal; nearly equal in size, except the piece on the left of the anal pieces, which is nearly twice as large as either of the others; articulating facet of the arms uneven; perforated; sulcated upon the upper side; the pieces curve upwards at their line of junction, and terminate upon the summit above the line of the arms.

Anal pieces two; hexagonal; one equaling in size the first radial pieces; the other is quite small.

Arms five; single; structure beyond the first joint unknown; they start from the body in a horizontal direction.

Column unknown.

Geological position and locality. Found in the limestone about five feet beneath the Devonian black slate, and above the beds of Hydraulic cement-stone, Jefferson county, and in the same geological position on the falls of the Ohio. It does not appear, from what is known of it, to have a very great vertical range, probably not more than three or four feet.

OLIVANITES VERNEUILII. *Troost.*

Ref. and Syn. Pentremites Verneuilii, Troost, sixth report on the Geology of the State of Tennessee, Nashville, 1841. *Pentremites Verneuilii (Beadle) d'Orbigny Prodrome de Pal., Stratigr* 1, *p.* 102.

Elæacrinus Verneuilii Roemer. Monographie der Fossilen Crinoiden familie der Blastoideen, &c., Berlin, 1852, *p.* 59.

This fossil is found in great abundance in rocks of the Denovian period, at the Falls of the Ohio river, and on Beargrass creek near Louisville, Jefferson county, Kentucky, and in other localities.

Professor Troost distinguished this fossil in 1841, as *Pentremites Verneuilii.* In a list of fossil crinoids of Tennessee, published in the proceedings of the American Association for the Advancement of Science; of the meeting held at Cambridge, Boston, 1850, the learned professor has removed it from *Pentremites;* having erected a new genus for its reception, and distinguished it as *Olivanites Verneuilii.* In a private letter, written August 3d, 1849, to a distinguished lady of Tennessee, Professor Troost removes *Pentremites Verneuilii* to *Olivanites.*

Dr. Fred. Roemer, in an elaborate and able work on the Family Blastoidea, referred to above, has re-described this fossil under the generic title of *Elæacrinus,* (retaining Prof. Troost's specific name,) with excellent figures by Hugo Troschel. For want of well preserved specimens, both the figures and description are defective in many respects.

For these reasons, and possessing quite perfect specimens, it is proposed to describe these, and restore the name proposed by that pioneer of western geology, Dr. Troost.

During the last seventeen years hundreds of these curious forms, known as "Petrified Hickorynuts," have passed through our hands, having been distributed to collectors at home and abroad. Dr. Roe-

mer's description was probably made from some of those furnished by us during his visit to this country.

Of the multitudes collected we have now over three hundred specimens, and out of this large number, not more than five or six expose the true structure of the body, especially the arrangement of the base, and only two exhibit the pieces at the summit of it.

OLIVANITES VERNEUILII. *Troost.*

(Plate V. fig. 1, 1 *a*, 1 *b*, 1 *c*, 1 *d*.)

Description.—The body is ellipsoidal; the usual proportion between the height and width is as 4 to 3; in the more globose it is sometimes as 3 is to $2\frac{8}{10}$. The whole surface in well preserved specimens, shows a remarkable fine sculpture. The cup, below the ambulacral fields, consists of eleven pieces; above the cup and between it and the summit are four interradial lanceolate pieces, one anal piece, five pseudambulacræ, and ten large pieces; one on either side of these, making thirty-six prominent pieces, exclusive of those at the summit; making in all about fifty pieces. Only very short pieces of the column having been found attached, little of its structure is known; the small part found attached is round or imperfectly pentagonal. The columnar perforation is pentalobate.*

The *Basal pieces*, three in number, are very minute; lozenge shaped or quadrilateral; situated at the bottom of the columnar-pit; always concealed when the column is present.

Primary radials are also three in number; small; situated within the columnar pit; two are hexagonal, and one somewhat lozenge-shaped; nearly of equal size; each piece is ornamented by three tuburcles, one on either side of the sutures, near the outer margin of the joined pieces, and one near the center of the pieces; they are usually entirely concealed by the column—a single specimen has been seen that exhibited a part of these pieces when the column was present.

Primary radials, second series. These pieces are five in number; forked; one-sixth wider, at the spread of the branches, than high; the inferior margin is deflected within the columnar-pit, and rests on the outer or superior margins of the first radials, as in *Pentremites*, with this difference, one of the second radials rises from an angular point of

*A single specimen, out of many, exhibits this structure; nearly all the specimens are partially silicified, and the structure partially obliterated.

one of the hexagonal pieces. The bending or angular deflection of these pieces, into the columnar-pit, is most remarkable, forming, as they do, a margin about equal to their thickness around the external margin of the columnar-pit, around the column presenting the appearance as if their junction with the first primary radials was against their inner face, and not by the inferior margin of the pieces, as is usually the case with crinoidea. The sides of the pieces or branches of the forks are nearly of equal width, tapering or curving slightly from within the fork outward; the lateral margins are straight; their summits are variously truncated, sometimes by a straight line from within the fork outward and downward; again, by an additional corner removed from the point within the fork, and sometimes they are found irregularly rounded from the center of the branches to either side; all these forms are seen in a single specimen. The angular indentation between the branches of the fork terminates in a prominent cup, from which proceeds, upward, on either branch of the fork, defining the space between them, a sharp prominent margin marking the limit of the branches of the fork. The branches of the second primary radials are also marked with lines of increment, which conform to the upper and outer margins of the pieces. The lines are prominent, and are probably the remains of the processes marking the margins of the pieces above alluded to.

Interradial pieces—(No. 4, fig. 1, plate v.) These five pieces are long, (seven times as long as their greatest width;) lanceolate, rising from the notched and curved superior margins of two adjacent branches of the second primary radial pieces, and terminating at the summit of the body, between the ovarial (?) openings; they are divided longitudinally by a line from which fine depressed striæ diverge at an angle of abont 60° (upward and outward,) dividing the parts of the piece on either side of the center line into flat bands, equal in width to the ribs on the pieces on either side of the pseudambulacral fields, and the pieces composing these, the ambulacræ—sixty of which are contained in an inch.*

The parts here designated interradial pieces, in the best preserved

* Dr. Roemer's figure represents this part, which is the middle of his "*deltoid* pieces," as covered with punctures, ("*chagrinartig bedect.*") In the above description this part is called interradial piece, and is separated from the pseudambulacral fields, and from the spaces on either side of them. In no specimen, of thousands, has this punctured surface been observed; it is probably the effect of cleaning with a pointed instrument. It has been observed in some so clean ed.

specimens, are separated from the pieces on either side of the pseudambulacræ, by a sharply defined angular ridge, surrounding the whole piece except at the junction with the branches of the radials below it.

Anal piece. This piece is wider than the interradial pieces; nearly equal in width in its whole length; rounded at its summit, having a circular notch in its upper margin, the sides of which are frequently truncated obliquely downward from the sides of the notch, above which is situated the large ovoid opening. It rises from the summits of the second radials, like the interradial pieces, and like those it is marked with striæ. This piece has much irregularity in form and adjustment with reference to the body, in different specimens, being disposed above the general surface at its superior extremity, and sometimes below it; frequently the circular notch occupies the whole summit of the piece, which is then very prominent, and prolonged above the summit of the body, while in other specimens it terminates a considerable distance below the summit.

The pseudambulacral fields, five in number, rise from the angular notch in the summits of the second radials, and terminate at the summit; they are alike in size and arrangement of parts; each field consists of three parts, the middle of which is the longest; rising from the bottom of the notch, as before stated, it is continued to the openings around the summit, which it divides, and is continued beyond them toward the center of the crown, and is lost under the small pieces arranged within the openings. It is divided by a line into equal parts running its whole length, each of which is again divided into a line of pores, and a ridge. In some states of specimens the mesial line is deeply grooved, on either side of which is a rounded ridge, equal in width to the line of pores; thus each field is divided into four parts of equal width—i. e., two lines of pores and two ridges lying between them. In large specimens their width is $.\frac{15}{100}$ of an inch. The pores are ovoid, the long diameter lying transversely with the specimen, about 60 to the inch; they terminate at the reniform larger openings at the summit. The openings at the summit have their long diameter parallel to the length of the pore pieces.

The sides of the suture dividing the pore pieces is beautifully ornamented by fan-like figures, lying nearly opposite the pores; they are nearly triangular in form, composed of six diverging ridges, having a

common origin opposite the pores; these are divided by grooves of unequal depth, increasing in size and depth from the origin of the ridges to the bottom of the groove, quite analogous to the same part in *Pentremites obesus*.

The pores communicate with the interior of the body. On either side the pore pieces are supported by a piece, two to each field, ten in all, of equal width, nearly of the same form, ornamented with grooves and ridges. The grooves rise at a pore, and cross the pieces transversely, and terminate against the interradial pieces, the whole surface of the pieces being covered by grooves and ridges, which are equal in size to the pore, or the division between the pores, against which they severally originate. These are again crossed obliquely from the outside of the pieces upward, by a set of ribs which rise against the interradials and anal piece, and cross the supporting pieces of the pseudambulacræ.

The summit within the circle of the large pores (ovarian openings ?) is divided into about twenty-two small pieces, six of which are disposed around the seventh, which occupies the centre of the crown. They are nearly of equal size, polygonal or nearly circular; without the line of the six pieces, and falling into the indentations around the circle formed by them, are smaller pieces, and on either side of the outer circle of the ovarian (?) openings are small linear pieces, abutting against the small pieces outside of the first circle; all the pieces exept the linear ones are studded with a number of small prominent granules.

Specimens of this fossil are found ranging from $.\frac{30}{100}$ in inch, to an inch and $.\frac{50}{100}$ in length.

The relative proportion of one of the medium sized, rather globose specimens is as follows:

Greatest length, - - - - - - -	$1.\frac{26}{100}$ inches.
Length from bottom of columnar-pit to summit,	$1.\frac{15}{100}$ inches.
Greatest diameter, - - - - - -	$1.\frac{15}{100}$ inches.
Least diameter, - - - - - -	$1.\frac{10}{100}$ inches.
Length of second primary radials, - - -	$.\frac{25}{100}$ inch.
Length of first primary radials, - - -	$.\frac{12}{100}$ inch.
Length of basal pieces, - - - - -	$.\frac{09}{100}$ inch.
Greatest length of the pieces, - - -	$1.\frac{20}{100}$ inches.
Greatest width of pseudambulacral fields, -	$.\frac{56}{100}$ inch.

Greatest width of interradial pieces, - -	.$\frac{15}{100}$ inch.
Greatest length of interradial pieces, - -	1.$\frac{07}{100}$ inches.
Greatest width of anal piece, - - - -	.$\frac{30}{100}$ inch.
Greatest length of anal piece, - - -	1.$\frac{06}{100}$ inches.
Diameter of columnar pit, - - - -	.$\frac{15}{100}$ inch.

Geological positiom and locality.—Found in rocks of the Denovian period, about five or six feet below the hydraulic cement-beds, in a rock of peculiar physical character, distinguished as the *Olivanite* bed; the bed varies in thickness from one inch to two feet. The space between the *Olivanite* bed and the hydraulic cement beds, abounds in fragments of *Spirifer cultrajugatus*, and affords very few fossils, except a few washed and rolled corals. The *Olivanite* bed is rather local, although these fossils have a large horizontal range, the beds are in interrupted patches. The beds at the Falls of the Ohio have probably been the most productive. They have also been found on Beargrass creek, Jefferson county, near Louisville; on Silver and Fourteen-mile creeks, Clarke county, Indiana; and near Columbus, Ohio.

OLIVANITES ANGULARIS. *Lyon.*

The preservation of the specimens of this species is such, that a distinct character cannot be traced of the fine external markings. The general arrangement of the parts, however, are distinctly visible, warranting the opinion, that the generic character is that of *Olivanites*, although some of the parts are not distinctly preserved.

Specific Character—Plate V. fig. 2, 2 *a*, 2 *b*.

Description.—The body is sub-ovoid; the diameter of the specimen under consideration, from the anal side, transversely, to the highest point on the opposite side, is .$\frac{85}{100}$ of an inch; the diameter parallel with the flattened anal side .$\frac{75}{100}$ of an inch; the height being .$\frac{75}{100}$ of an inch. The anal side between the pore pieces, on either side of it, is nearly twice as wide as either of the other sides. The outline is very much inflated on the line of the pore pieces, whilst the interradials are deeply seated in the groove between them. The pseudambulacral fields rise sharply angular from the interradial pieces, which are much wider, and consequently have a much more rapid taper than the same pieces in *Olivanites Verneuilii*. The pseudambulacral fields are also narrower in proportion than in that species; the summit and basal

extremity are broader and flatter. The first series of primary radials are prominent, and raise out of the basal pit, which they do not in *Olivanites Verneuilii.* Viewed from either end, this species presents an irregularly sided pentagon, the bounding lines of which are concave toward the body of the specimen. This striking difference of section transversely, will at once distinguish this from *O. Verneuilii.*

Geological position and locality.—A few specimens of this species have been found in the rocks of the Denovian period, lying between the black slate and the hydraulic cement beds at Rock Island, at the foot of the Falls of the Ohio; on Beargrass creek, near Louisville; also, on Silver creek, Clarke county, Indiana. They have a limited vertical range, and are only found near the base of the beds in which they occur. *Olivanites Verneuilii* does not, so far as our observation extends, rise into the beds above the hydraulic beds, in which it is not found.

CODASTER ALTERNATUS. *Lyon.*

(Plate 3, 3 *a*, 3 *b*.)

Body long; irregularly conical; summit level in the centre; sloping slightly toward the outer end of the pseudambulacral fields; horizontal section at the lower extremity of the fields pentagonal, the angles of the pentagon being at the ends of the pseudambulacral field.

Basal pieces three; pentagonal; of equal size; gibbous; when joined forming a minute triangular cup, larger than the inferior extremity of the joined first radials fitting upon it; perforated in the centre by a very small circular opening.

Radial pieces three—two hexagonal complete, one pentagonal, and incomplete, (as in *pentremites*); the upper margin of the hexagonal pieces are concave in the centre, the corners obliquely truncated, forming, with the pentagonal piece, a deep cup, having the upper margin indented with two concave and three angular notches, from which rise five radials of the second series, two fitting upon the concave notches at the summits of the complete pieces; the other three rising from the angular notches between the three pieces.

Radial pieces, second series, five; reaching the summit; twice as long as wide; the summit of each indented by an angular notch, broader than deep; rising from the base of each, and tapering to a point at the inferior extremities of the notches, is an elevated rounded

rib, ornamented transversely by fine rounded striæ, while the margins of the pieces are similarly ornamented, by coarser striæ, lying parallel with the margin of the pieces, and terminating against the sides of the rib which occupies the middle. The sides of the second primary radials are sometimes closed upon the summit, nearly obliterating the triangular field between the pseudambulacral fields. The mesial line is always straight. The mouth seems to be situated at the centre of the summit, from which proceed five minutely granulated, porous, pseudambalacræ, terminating at the angular corners of the summit, in the notch of the second primary radials, forming a prominent ridge, divided, longitudinally, into four equal parts by three indented lines, the deepest of which rises within the mouth. The spaces on either side of the middle suture are divided by small prominences, diverging from the suture, and terminating within a circular depression, on the inner margin of the outer spaces. Around the mouth, at the junction of the ambulacral fields, are five rounded prominent tubercles—above the ovarial opening, in some specimens, another is added, which is still more prominent; from four of these tubercles diverge four prominent ridges, tapering from the mouth outward, one to the middle of four of the straight sides, the fifth space is without a ridge, being occupied by an ovate or circular (ovarial or anal) opening. The depressed, triangular intervening spaces are filled with seven or more thin pieces, lying parallel to the pseudambulacral fields, articulating with the summit of the second radial, and the prominent ridge lying between the pseudambulacræ. These pieces were evidently capable of being compressed or depressed; the point at the lateral junction of the second radials is in some specimens folded over toward the mouth so much as to entirely obscure these triangular spaces by covering them.

The ovarial or anal opening is always over the radial, to the right of the incomplete first radial.

Columnar facet small, round, or obscurely pentagonal. *C. alternatus* differs from *C. acutus* and *trilobatus*, *McCay*, in its greater length, and the rib ornamenting the second radials; also, by the much greater delicacy, (judging from McCay's figure,) of the ridge between the ambulacræ. This species is found much below either of the species of McCay.

Geological position and locality. Found in earthy partings between chrystalline limestone, about eight feet below the hydraulic cement beds,* and below the *Olivanite* horizon at the falls of the Ohio, and in the same geological position on south fork of Beargrass creek, Jefferson county, Kentucky.

Length of specimen, - - - - - - $.\frac{75}{100}$ inch.
Greatest diameter, - - - - - - $.\frac{38}{100}$ inch.

For valuable hints and assistance our thanks are due to Dr. D. D. Owen; also, to Samuel Casseday, for the use of his cabinet of *Crinoidea* and *Olivanites*.

SIDNEY S. LYON,
Assistant Geologist.

*These rocks belong to the Devonian period.

Explanations of the Plates.

PLATE I.

ASTEROCRINUS CORONARIUS. *Lyon.*
Volume 3, *page* 476.

FIG. 2. View of the summit.
FIG. 1a. Basal view of same specimen, natural size.

GRAPHIOCRINUS—14 BRACHIALIS. *Lyon.*
Volume 3, *page* 479.

FIG. 2. Generic figure, representing the parts laid out upon a horizontal surface. 1. Basal pieces. 2. First radial pieces. 3. Second radials. 4. Secondary radials. 5. Arms. 6. Anal pieces.
FIG. 2a. Profile view, same specimen.
FIG. 2b. Basal view, same specimen, natural size.

PLATE II.

PENTREMITES OBESUS. *Lyon.*

Volume 3, *page* 469.

FIG. 1. Basal view.
FIG. 1a. View of the summit, same specimen.
FIG. 1b. Profile view, same specimen.
FIG. 1c. Basal pieces.
FIG. 1d. Fragment showing the interradial pieces, drawn the size of nature.
FIG. 1e. Generic figure, reduced one diameter—
1. Basal pieces. 2. First radial pieces. 3. second radial pieces. 4. Third radial pieces. 5. Interradial pieces. 6. Pseudambulacral fields.

PLATE III.

ASTEROCRINUS CAPITALIS. *Lyon.*

Volume 3, *page* 472.

FIG. 1. Profile view, (all the figures are the size of nature.)
FIG. 1a. View of one of the club-like lobes, presenting its smallest surface.
FIG. 1b. View of same part, presenting its greatest surface.
FIG. 1c. View of the summit.
FIG. 1d. Basal view.
FIG. 1e. Generic figure—
1. Basal pieces. 2. Radial pieces. 2a. Anal piece. 3. Secondary radials.
FIG. 1f. End view of the base, anal side presented.
FIG. 1g. External view of the base.
FIG. 1h. Internal view of the base.
FIG. 1i. End of the base, opposite the anal side.
FIG. 1k. End view of the base, showing the long diameter.

PLATE IV.

ACTINOCRINUS ABNORMIS. *Lyon.*

Volume 3, *page* 479.

FIG. 1. Profile view, natural size.
FIG. 1a. Basal view, same specimen.
FIG. 1b. Generic view, extended from the anal pieces to the knob at the center o the summit.

DOLATOCRINUS LACUS. *Lyon.*

Volume 3, *page* 482.

FIG. 2. Generic figure.

FIG. 2a. Summit view.

FIG. 2b. Basal view, same specimen, size of nature.

VASOCRINUS VALENS. *Lyon.*

Volume 3, *page* 485.

FIG. 3. Generic figure, size of nature, the pieces arranged around the columnar facet.

FIG. 3a. Profile view, *vasocrinus valens.*

FIG. 3b. *Vasocrinus sculptus*, from which the external sculpture has been removed, anal side front, natural size.

VASOCRINUS SCULPTUS. *Lyon.*

Volume 3, *page* 486.

FIG. 3c. Profile view, natural size, different specimen.

FIG. 3d. Basal view of same specimen.

FIG. 3e. Summit view of same specimen, natural size.

PLATE V.

OLIVANITES VERNEUILII. *Troost.*

Volume 3, *page* 487 ,488.

FIG. 1. *Olivanites Verneuilii*, natural size, anal side front.

FIG. 1a. *Olivanites Verneuilii*, natural size, side opposite the anal side.

FIG. 1b. Generic figure—1. Basal pieces (lighter colored.) 2. Primary radials, 1st series. 3. Primary radials, 2d series, (forked pieces.) 5. Interradial pieces. 4. Pseudambulacral fields, and supporting pieces on either side. 4'. Anal piece, with the large opening at the summit. 6. Small pieces at the summit.

FIG. 1c. Summit view, natural size.

FIG. 1d. Basal view, natural size.

OLIVANITES ANGULARIS. *Lyon.*

Volume 3, *page* 492.

FIG. 2a. *Olivanites Angularis*, anal side front, natural size, from a large specimen.

FIG. 2b. *Olivanites Angularis*, summit view.

FIG. 2. *Olivanites Angularis*, side opposite the anal side.

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CODASTER ATTEN~~T~~ATUS. *Lyon.*

Volume 3, *page* 403.

FIG. 3. Generic figure—1. Basal pieces. 2. Radial pieces, 1st series. 3. Radial pieces, 2d series. 4. Angular pieces, on the summit, occupying a position in reference to the 2d radials, similar to the interradial pieces in *Pentremites*.

FIG. 3a. Summit view, enlarged two diameters.

FIG. 3b. Profile view, natural size.

SIDNEY S. LYON.

PALÆONTOLOGICAL REPORT

OF THE

FOSSIL FLORA OF THE COAL MEASURES

OF THE

WESTERN KENTUCKY COAL FIELD:

BY

LEO LESQUEREUX,

PALÆONTOLOGIST.

INTRODUCTORY LETTER.

DEAR SIR: I herewith submit my report on the identification of the veins of the Southwestern Coal Measures of Kentucky.

Permit me first to most gratefully acknowledge the liberal and enlighteded support that I received from you, to ensure the success of my researches. It is by following exactly your directions, that with the co-operation of Mr. E. T. Cox, your able assistant, we are able to point out now, for the first time, some general and reliable characters, which may prove of practical advantage for the identification of the richest beds of coal of Kentucky, and of the whole coal-fields of the United States.

It was understood that I should only have to collect and examine the fossil plants of the Western Coal Fields of Kentucky, with essential references to the peculiar species of each bed of coal. You wanted thus to ascertain the practicability of establishing the order of superposition, and by this means, the identification of the beds. I had been engaged during two years, in following the same researches for the state survey of Pennsylvania, in the anthracite coal-fields of that state, and had obtained some interesting and practical results from the study of the fossil plants found in connection with the shales of each bed of coal. But as soon as we began our explorations, in the bituminous coal-fields of Kentucky, it became evident that the marine element was predominant in the shales of most of the beds, and that it would be of little advantage to limit our researches to the fossil botany only, since shells and remains of fishes were mostly found in the shales, without any plants whatever. For that reason, and confident that the general principles exposed hereafter, would prove reliable for the distribution of the shells, as well as of plants, I determined to carefully examine the marine remains of each bed, and to collect them for comparison and study.

Mr. E. T. Cox, who is entitled to his share of the practical results of our explorations, being better acquainted with the shells than I am, took especial care of this part of our work, and by his unremitting researches, and arduous labor, we have been able to collect a large num-

ber of specimens, which have been subjected to your examination. From them it is evident that the distribution of the species of shells in the shales of a bed of coal is as reliable, for its identification, as the distribution of the species of fossil plants.

The following introductory remarks may appear out of place in a local report like this, but I think that they are not without a practical advantage. They will give not only an answer to a question scarcely understood as yet, and often put to us by persons interested in the coal business, viz: what is the coal, and how has this fuel been formed? But they will also enable the reader fully to understand the practical deductions, and to test their value.

It is unnecessary to dwell on the advantages of undoubtedly ascertaining the geological level of a bed of coal, since it is evident that profitable explorations for coal can be made, with some chances of success, only from the directions of a previously ascertained and well established geological level. When this is exactly ascertained, a single glance at a vertical section of the measures gives an answer to the question: at what distance above or below shall we expect to find another coal, and what will possibly be the thickness of the bed?

The few quotations and references to researches previously made by myself, in the coal-fields of Pennsylvania and Ohio, will be easily excused, since they tend to solve the problem of the coeval formation, even of the primitive connection of all the coal-fields of the United States—a question most interesting for geology, and eagerly discussed just now. And as for the right I may have to quote a few lines of a report delivered in 1854, to the director of the Geological State Survey of Pennsylvania, and of which a small pamphlet, "*Description of new species of fossil plants, &c.,*" has only been published, I do not think that it can be denied me. This report, elaborated with great care, and the arduous labor of two years, was to appear in the final report of the Geological State Survey of Pennsylvania, but it is a question if it will ever be published. Therefore, I do not think that I am bound to entirely disregard some scientific results, which may be of general advantage, for the only reason that they have been made under the direction of another state.

I am, sir, most respectfully, yours,

LEO LESQUEREUX.

DR. D. D. OWEN, *Director of the State Survey of Kentucky.*

INTRODUCTORY REMARKS.

In tracing the features, and studying the rocks and compounds of the earth's surface, no problem has more frequently occupied the mind of geologists than the formation of coal. Where does this black substance come from, hard as stone, and nevertheless inflamable as wood; half bitumen, half charcoal, encased between beds of shale and rock, which, by their fossil remains, their fishes, shells, or plants, attest the highest antiquity? Has coal been originated in the bowels of the earth by some volcanic agency, and deposited in a fluid state, like the lavas or the primitive rocks of many mountains? No! for it is stratified, laminated, extended in horizontal beds, covering very large surfaces with a nearly constant thickness. Moreover, the shales in which it is ordinarily incased bear evident proofs that they have been slowly deposited in a quiet water basin, and that subterranean fire has had no action upon them, except perhaps as a hardening agency. Or, perhaps, has coal been made of the remains of extensive forests, overthrown, transported, and deposited again in valleys and hollows, by an universal flood. But, by such a cataclysm, those remains could not have been distributed in an harmonious manner, in extensive beds of equal thickness, and especially in such purity that they scarcely contain any particle of mud, sand, or any substance that does not belong to the chemical compounds of the wood. For the same reason, also, the beds of coal cannot be the result of heaps of drift-wood along the banks of the large rivers, or on the shores of the sea. It is then necessary to admit, with most of the best living geologists, that the coal beds have been formed nearly in the same manner as the peat-bogs of our own time, and that the coal itself is nothing else but decomposed and hardened woody matter, remains of immense and successive forests, grown, decayed, heaped up, and then entombed on the spot, in their gigantic shrouds of black slate, of black, white, and grey limestones, or of yellow sandstone.

But such an explanation is too general, too indefinite, to be easily understood, and especially to give a satisfactory account of the various

accidents which have accompanied the formation of the coal. And since it is, from the nature of the shales of the coal-beds, and from the remains, whether plants or animals, found in connection with them, that the writer of this report intends taking the characters that may help to their identification, or to the ascertaining of their geological level, it is necessary to give, at least, the details that may be justly required, as reliable proofs of the validity of his opinion.

The vegetable is cotemporary with the animal kingdom. Plants and animals have appeared at the same time on the earth, and grown together in parallel lines—for the remains of marine plants or fucoides are found in the oldest stratified rocks, in connection with the petrified remains of shells. As soon as a part of the earth's surface has been thrown out of the sea, like a new-born child, nature, its kind mother, has covered it with the green carpet of another vegetation. But the rise of a solid surface above the sea does not appear to have been a sudden and paroxismal event. Impelled by the action of an internal fire, the crust of the earth, still thin and scarcely solid, was continually swelling here and there, with a variety of undulating movements—ascending and then subsiding at the same place—either propelled by the internal fire, or depressed by its own weight, when the force lost its energy. In this manner, ranges of hills began to appear, breaking the monotonous horizon of an universal ocean; and at their base, immense plains, leveled by the long protracted action of the waves, being by and by raised to the surface and separated from the sea by heavy banks of sand, were thus transformed into shallow marshes, prepared for another kind of vegetation. Such marshes though. of a far more limited extent, are seen in our time along the shores, both of the Atlantic and of our great lakes, the Dismal and Alligator swamps of the south; the Sandusky, Montezuma, and Toledo marshes of the north.

But before those immense plains were thus slowly elevated and separated from the vast deep, the sea came for a long time, breaking its waves against the primitive hills, or at least, was long engaged in depositing around their base the mud with which its waters were charged. Those gigantic deposits of red sandstone, bordering the coal basin on its eastern margins, are especially the work of the tides. Like the conglomerates which were afterwards deposited upon them, they thicken to the east, and nearly disappear in the contrary direction, evidently

showing where then were the first shores of the ocean—the first outline of the Alleghany mountains perhaps.

The conglomerates of the anthracite basins of Pennsylvania are about fifteen hundred feet high, composed of sand and pebbles of quartz, which are sometimes as large as hens' eggs. On the contrary, in the western part of the Coal Measures, in Indiana, Kentucky, and Tennessee, they are comparatively thin, and of a finer texture—just as it happens that near the shallow shores of our lakes, or of the Atlantic, the gravel and coarse materials of the bottom are heaped by the waves nearer to the margin, in proportion to their size, the finest particles of sand being necessarily drawn farther from the shores where the action of the waves is less violent. It was in this manner that the first basin of the coal was prepared. Bordered to the east by a chain of hills, the bottom was slowly upheaved, and the ocean damed far away to the west, began there, by its perpetual movements, to build again its new shores, and to close in the coal basin with high banks of sand and gravel. This separation was necessary, for a shallow, quiet, water, of a constant level, is the first condition of the formation of peat, and consequently of coal.

The plants of the bogs have a peculiar growth and a peculiar composition. They live ordinarily half immersed in water, and raise their stems, branches, leaves, and flowers above the surface. They are generally of a woody texture. Even the mosses and the grasses of a peat-bog contain, comparatively to their size, as much woody fibre as the hardest oak. The trees are most of them resinous. In the northern part of the United States the balsam-fir, the black and white spruce, the tamarack, the arbor-vitæ and the white cedar; in the south, the bald cypress, the great and small laurel magnolias, the tulip-tree, are commonly seen growing on the cedar swamps, with birches, alders, poplars, and other resinous shrubs. The peat bogs of Europe are abundantly covered with a kind of dwarf-pine, from the leaves and twigs of which the rosin trickles upon the mossy ground, forming all around the trees a hard floor of tar many inches in thickness. Most of the plants of those marshes, except a few trees, belong to that peculiar station; they do not grow out of their bogs, neither can they be transported and cultivated out of them. For that reason the vegetation of the cedar swamps cannot be taken as a true representative of

the flora of a whole country. It has its place in the harmony of nature, like the fruits and flowers of our gardens, the grass of the prairie, the trees of the forest. It was destined for the condensation, the preservation of carbon, for the formation of coal. For truly, when we examine fossil plants that have been preserved in the shales of the coal, or when we analyze the substance of the coal itself, we find that the plants which formed it have the greatest likeness to those of our actual peat-bogs, viz: the ferns, the club-mosses, the horse-tails, the rushes, the reeds, and especially the resinous trees. The most remarkable difference is that all these plants, compared with those of our time, were of a monstrous size. They were, indeed, the mastodons, the mammoths, of the vegetable world.

Every body is now acquainted with Liebig's explanation of the combustion and decomposition of wood. When heat is applied to it, it burns with flame, developing carburetted hydrogen. When woody fibre is brought into contact with air, in a moist condition, it is gradually decayed, viz: changed into mould or humus, by the conversion of the oxygen of the air into the same volume of carbonic acid. Its carbon is then not only preserved, but augmented. When the access of air is restrained, decay, or a slow burning of the wood, is in like manner produced, but the process is different. The disengagement of carbonic acid, though continuous, is slight, and the final result is charcoal, wood-coal, lignite, mineral-coal, anthracite, even diamond, according to the conditions under which this slow burning has taken place—the quantity of water, the more or less free access of the oxygen of the air, compression, heat, &c. Says Liebig: "A slow but continual removal of oxygen in the form of carbonic acid, from layers of wood-coal, or of wood immersed and decomposing in water, transforms necessarily the woody substance into mineral coal. On the contrary, the removal of all the hydrogen of mineral coal, converts it into anthracite." From this we draw the conclusion, that for the formation of coal, a large production of woody fibre, at a constant water level, is a necessary condition.

The presence of the water, and its constant level, are necessary not only to prevent a too rapid decomposition of the wood, but also for the vegetation, itself, of the marshes. Plants living entirely immersed in water, do not have a larger proportion of woody fibre in their tissues.

The fucoides, or marine weeds, are of this kind. To elaborate wood, the plant wants the contact of the air with the porous surface of its leaves. The marsh plants, then, having their roots fixed in the ground below water, expand their leaves either on the surface of the water or above it. Trees need, for their vegetation, the absorption of air through their roots. Hence, those which grow on the bogs, extend their roots and rootlets in a large circuit, let them run near the surface among the mosses, and ordinarily plant themselves on a higher level, either on the decayed trunks of other trees, or on some heap of matter. In any case, a formation of peat is impossible in a marine basin not entirely secured against the action of the tides, or in the marshes of rivers, which, though covered with high water in the spring, become dried by the heat of the summer months. Along the shores of the ocean, of our lakes or our large rivers, there are extensive marshes, inaccessible during the spring, and even during part of the summer, covered with rushes and reeds, the bottom of which is constantly and slowly elevated by thin layers of mud or clay, but never covered with peat.

The same phenomenon is produced in lakes and bayous, where water is too high for the growth of the plants, and on the borders of which the water level is not constant. The matter deposited at the bottom of those deep marshes is constantly a fine mud.

There is perhaps no place in the world where the process of the formation of coal may be studied, with better chances of a clear elucidation of all its phenomena, than in the Dismal and Alligator swamps of southern Virginia and North Carolina. The extent, though truly nothing compared with the area of the coal-fields of America, covers, nevertheless, thousands of square miles. They are separated from the bays and sounds that surrounds them by broad hills, and large banks of sand, bordering the Atlantic, in a continuous row, from Cape Henry, or Norfolk in Virginia, to the mouth of Cape Fear river, or Wilmington in North Carolina. They contain, in their wide area, sand hills, deep deposits of peat, and lakes. The hills are covered with the vegetation of dry land. The peat, from one to fifteen feet thick, follows at its bottom the irregularities of the surface on which it rests, thinning and disappearing entirely where it abuts against the hills: for a bed of peat, depending for its formation on the level of the water,

has just the same appearance, or at least, by a cross-section, would present the same front as the transverse soundings of a shallow sheet of water.

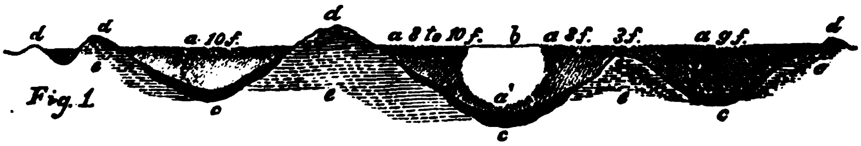

*Fig. 1. *Approximate section across the Dismal Swamp*—*a*. Deposits of peat. *a'*. Deposits of trees at the bottom of Drummond's lake. *b*. Surface of lake Drummond. *c*. White clay of the bottom. *d*. Hills of sand. *e*. Sand below the marshes.

As for the vegetation itself, and its action on the formation of the peat, let any tourist try to find his way directly across the swamp, from some point on the canal to Drummond's lake and he will understand at once all about the mystery of the heaping of vegetable matter. Wading at least knee deep in water, or in a black soft mud, or sinking at every step deeper and deeper in the hillocks of green mosses, where he thought to find a dry and solid footing for a minute's rest, he has literally to cut a path through a wall of canes, of reeds, and of shrubs. The only place where he finds firm stepping and a clear space, is on the roots of the bald cypress, which raise themselves above the water around each tree, like the scalped skulls of a tribe of Indians; or, perhaps, on the prostrated trunk of a huge magnolia tree, covered with mosses, and slowly sinking in its muddy grave, not to decay, but to be embalmed and preserved like an Egyptian mummy. Every year the mingled mass of vegetation, the mosses, the canes, the reeds, the trunks, branches and leaves of the trees and shrubs, are heaped and deposited on the surface of the bog, to be, by and by, transformed into combustible matter, by the process of slow decomposition.

Some of the lakes now open on the surface of the marshes have certainly been hidden, formerly, by a thick coat of vegetation. Drummond's lake is only fifteen feet deep, and its bottom is strewn with the remains of an overthrown forest, which has probably sunk by its own weight. Phenomena like this are frequent in the large peat-bogs of northern Europe, especially in Sweden, Denmark—even in the mountains of Switzerland. The green carpet of vegetation which, by

*The figure is drawn without reference to any exact proportions; in depth it represents about one foot in the 8th part of an inch; in length one inch would represent more than two miles.

the agency of floating mosses, spreads on such lakes, is sometimes so thin that it breaks under a light pressure, and men and animals are frequently engulfed and irretrievably lost in their treacherous waters. The rich cabinets of Lund and Copenhagen are filled with antiquities collected in the peat-bogs of that country—weapons and armor; ornaments of copper, silver and gold; tools and instruments of every description; bones and skulls of extinct or living races of animals; of men also; even the whole skeleton of a woman, with her clothes, have been found imbedded in the peat.

Drummond's lake has now been open for many hundred years; its black water has entombed its sunken forest under a bed of mud. The surface of the lake, like the general surface of the Dismal swamp, is only 16½ feet above mid-tide of the Atlantic. If we suppose a slow depression of all the space covered by the Alligator and Dismal swamps, of say only a few feet in a hundred years, what would be the result? At first the water rises above its former level, since its outlets are necessarily obstructed, and the remains of the plants still growing here and there upon the hillocks of the marsh, fall every year into the water and sink to the bottom—not to add any more matter to the bed of the peat, but to be incorporated with the soft mud continually deposited by the water. If the downward movement continues, every trace of vegetation must disappear, and the marsh forms an extensive lake, connected by some outlet with the sea, which brings to it a few species of its inhabitants, either fishes or molluscs; and, by and by, after a still lower depression, either the sea spreads quietly over the whole space, and its water covers it with a deposit of limestone, wherein are imbedded the remains of the shells and animals of the deep; or, perhaps, after a sudden cataclysm, there is a depression of a few feet, and the sea, overcoming its barriers, rushes into its old level, sweeps over its old bed with impetuosity, and brings with its waves the banks of sand and the gravel of its shores, to scatter them more or less irregularly over the whole surface. Let the land rise and the water recede again, and the formation may be repeated many times, with many modifications. This simple work of nature, operating in this wise for an immense number of centuries, will necessarily result in the transformation of the whole stratum to true Coal Measures. The compressed and crystallized peat will be the coal; the soft mud slowly deposited

upon it by quiet and shallow waters, will be hardened to black shales, and show us the petrified remains of plants, shells, or fishes. The deposits of the deep, quiet, marine waters, have formed a bed of limestone above it, and if, afterwards, sand has been brought in by the currents of the sea, the whole measures—coal, shales and limestone—become covered with sandstone.

The only thing not explained above, is the formation of the fire-clay of the bottom, which, by a cross-section, would certainly be found under the coal of the Dismal Swamp, as it is found under nearly every bed of the old Coal Measures.

As we have seen before, the woody matter deposited in a basin can only be preserved and transformed, if the water is of a constant level. Resting on the sand, the water percolates through it, and consequently is subject, by a constant motion, to a perpetual change of chemical constituents, and to a renewal of the particles of air which it contains. This change is opposed to the formation of peat, since water, before being prepared for the preservation and transformation of woody substance, has to become saturated with a peculiar acid—*the ulmic acid*—produced by the decomposition of wood itself. Thence it follows, that a peat or coal basin has to be separated and prepared to keep its water, like a well cemented cistern. This work is done by very small animals—*infusoria*—and by peculiar species of plants. In the peat formations of the present day the clay bottom of the bogs is prepared by fresh water molluscs and infusoria, and by the vegetation of the *characeæ* and *confervæ*, two families of cryptogamous plants, which disappear entirely, as soon as the peaty vegetation begins. They fix in their shells, or in their tissue, the carbonate of lime or the silica, abundantly dissolved in some water, and by their decomposition they deposit those substances at the bottom of the water in the form of a very fine mud. In Denmark, there are some perfectly isolated ponds, where this soft mud or clay is formed, by the agency of the above named animals and plants, at the rate of one foot and more in every five years.

As there is no bed of peat, but is underlaid by soft white clay, so there is no bed of mineral coal without its bottom of fire-clay, except when it has been deprived of it by some accidental circumstance. This fire-clay is free from remains of animals and shells, but it contains very abundantly the stems and leaves of a species of plant, *Stigmaria ficoi-*

des, (plate 7, fig. 2,) which undoubtedly, like the *Chara* and the *Horsetail* of our time, has especially contributed to fix the silica, and to precipitate it to the bottom with its remains.

In this abridged exposition we cannot discuss the value of any of the above made assertions. Nevertheless, not one of them has been admitted without a critical examination, and after its trnth has been ascertained by serious researches, or by reliable authorities.

The formation of the coal being thus understood in its whole, it is easy to draw from it the explanation of the different modifications of the Coal Measures, and to deduce some general rules for the identification of the veins.

1st. THE FIRE-CLAY.

This clay, ordinarily full of rootlets and stems of stigmaria, so generally underlays every bed of coal, and its general appearance and chemical elements are so much the same, that except, perhaps, for its general thickness, it cannot become a very reliable guide for the identification of the beds. Even its thickness is variable. It depends on the depth of the basin in which it is formed, and on the regularity of its bottom—thickening in the hollows, and sometimes entirely disappearing near the margins of the basin. Variously tinctured by more or less of oxide of iron, it is generally whitish, but sometimes as red as ochre, and even variegated like marble, in the same bed. The quantity of *stigmaria* found in it is as variable as its color, and as for its chemical elements they depend, like the color, on the mixture of iron and lime, especially silica and alumina, which are never uniformly distributed in a wide expanse of shallow water. This fire-clay of the Coal Measures appears sometimes alone, and without any bed of coal above it. In which case it may be intermixed with layers of shales, covered with the remains of plants, especially of ferns. Then it indicates only the place which was prepared for the vegetation of a bed of coal. Some accident—the shallowness of the water perhaps, or some disturbance of its level—has prevented the growth and accumulation of vegetable matter in sufficient abundance to form the coal. But the plants, growing upon the marsh, have been imbedded and preserved in the shales above the fire-clay as testimony to its natural destination. Nevertheless, those isolated beds of fire-clay, overlaid by plants, are not always barren of coal, and by following them to some distance the coal

is often found somewhere reposing on their surface. The fire-clay is generally a reliable guide for the identification of veins, when it separates two beds of coal, forming what is generally called a clay parting. In this case, it is ordinarily found, though of variable thickness, over a wide extent. But it is then formed like the shales; in some cases, it is even a true shale, and it is in the examination of the shales that the reason of its formation, and of its appearance, ought to be looked for.

2ND. THE COAL.

There is no substance of which so many chemical analyses have been made, and none, also, of which the chemical elements are so well known. The general result of all these analyses has proved a curious fact, viz: that two pieces of coal, taken from the same bed, at only a few feet distance, have scarcely ever presented exactly the same proportions in the quantity of their essential compounds. The reason of this is easily understood: each plant, especially each kind of tree, has for its wood a peculiar composition; each one is more or less resinous, hard or porous, has more or less of woody matter in an equal volume, and each plant has a peculiar acid; all the essential elements are locally preserved in the coal. The same remark is true of beds of peat, of which two slices cut either horizontally or vertically, at a distance of one or two feet from each other, never present exactly the same appearance, nor exhibit exactly the same proportion in their chemical elements. Some plants of the coal—the *Calamites* and the *Stigmaria* especially, fix in their tissue the silica of the water, and the quantity of ash varies in proportion to their abundance in the coal. Some others are porous, and when lying on the surface of a bed of coal, they let particles of mud percolate through, or within their tissue, and produce the same result in another way, and at another place. From these different causes, the ashes of the coal have a different color, and the distinction of white ash and red ash coal, which may be of great moment in the identification of the beds of part of a basin, is, when considered in a general point of view, of little value. If we may rely on the sections of the anthracite basins of Pennsylvania as they are generally given, the upper beds of it belong to the red, the intermediate ones to the grey, and the lower ones to the white ash series. In the coal-fields of western Kentucky and of Illinois, the upper beds of coal are white ash, the middle ones red, and the lower

grey or reddish.* The classification of the colors could not be more completely reversed.

This color of the ashes is probably, also, in immediate connection with the nature of the vegetation which has formed the coal. In the peat formations the matter formed by the heaping and decomposition of trees gives white ash; a compound of small herbaceous plants, ferns, rushes, canes, mosses, gives red ash; and a mixture of both forms the grey color of the ashes of some beds.

The external appearance of the coal is as much varied as its chemical elements. The trees, sometimes, when they are very resinous, have formed, by their decomposition, such a compact and homogeneous mass, that the coal receives a peculiar appearance; it is then known by the name of *cannel coal*. Another species of wood preserves, even in the coal, some trace of its primitive texture, and shows, in its fracture, a peculiar reflection of light, called, by the miners, the *birds eye*.

The coal is mostly stratified in thin laminæ or coats, alternately shining and dull—an appearance which clearly indicates an annual deposit of decayed vegetable matter, and the action of the water on it, during the winter time, or before the beginning of a new vegetation. The stratification of peat is exactly the same as that of coal; but the layers are variable in thickness, from the sixth of an inch to one inch and more, becoming natuarally thinner under a great compression, and nearer to the bottom of the beds.

The laminated appearance of coal is already a proof against the often repeated opinion, that it has been formed by the overthrow of vast forests; but there is a more conclusive argument against it. One acre of ground, covered with dense forest, and when its yield is carefully estimated, would afford, in 120 years, 10,450 cubic feet of wood; supposing the growth of peat to be only one foot in the same number of years, one acre of bog would produce 19,660 cubic feet of peat, (measured dry, and ready for burning.) A thick forest, overthrown by a cataclysm, and buried in the sand, would scarcely make three inches of coal. But some peat-bogs of Ireland, Germany and Switzerland, which have continuous beds of peat twelve to fifteen feet thick,

*Table of analyses of coal from saline and other localities, in the Geological report of saline coal mines and Manufacturing Co. p. 60, *by D. D. Owen, Cincinnati*, 1855.

would, if they were transformed into coal, produce three to five feet of hard mineral coal.

For a better understanding of the different features and various appearances of coal, it is necessary to remember that the woody substance in its decomposition or slow burning, and before arriving at its hardened state of mineral coal, is ordinarily subjected to a softening process. The low part of a bed of peat is, in most cases, a black paste. In the old lignite deposits of Germany, large trunks of trees, perfectly blackened, are heaped and flattened into beds of six feet to nine feet thick, and their woody substance has become so soft that the workmen can easily cut it with their shovels; hence the flattening of all the stems in the coal and the shales; the remarkable appearance of immense pieces of bark rolled and pressed together, like sheets of paper; hence, again, the compactness of some coals; the evident stratification or lamination of others; the remarkable action of the sulphuret of iron, in transforming into pyrites whole flattened stems, or in preserving in the cannel coal of Breckinridge the outlines of the stigmaria, and of their leaves, with such neatness that they look as if they had been painted in yellow, on a ground of black.

The thickness of a coal bed, notwithstanding contrary assertions, is scarcely a reliable guide for identification; though as it has been previously explained, the coal is formed on a continuous surface, and not deposited here and there in hollows of various extent, depth, and directions—for this thickness depends on the evenness of the bottom upon which it rests. When a bottom of sand, or of any other loose substance whatever, has been for a long time covered by a deep sea, it is mostly even and unbroken; a bed of coal formed upon it is generally of continous and of equal thickness. But when two beds of coal are only separated by a thin formation of sandstone, and consequently have been formed at a short interval from each other, the sandstone covering the lower bed often bears, on its surface, numerous wrinkles and furrows, as an evidence of the action of turbulent waters. In this case, the coal formed above it is only piecemeal, in separate layers, thick in places, then rapidly thinning until it disappears, to be again found at a distance of a medium thickness, and continue for a while.

3RD. THE SHALES OR ROOF SLATES.

The shales are mostly a compound of the finest particles of matter, deposited in such a way that they are generally laminated in thin sheets, probably a result of periodical influences. If the movement of depression, marked by the formation of the shales, has been as slow as all the appearances lead us to believe it, the water raised above the marshes, was at first nearly of the same depth, and covered the whole field. If we suppose that some essential elements of this water had the power of consolidating themselves, and of imbedding and preserving all the low plants and the leaves falling on the marshes from the trees; if we suppose further, that by breaking the hardened mould, we could still now find the remains of those plants perfectly well preserved in the stones, we cannot but admit that those prints of plants would give us a pretty exact idea of the vegetation of the marshes of the coal epoch. It is just what has happened. Whenever, during the formation of the shales, the movement of depression has been so slow that for a length of time the marine water has not invaded the marshes, the deposited shales contain remains of plants only; but when the depression has been somewhat more rapid, the deeper water has arrested the vegetation, and the scantily preserved remains of plants are old, much broken, mostly stems, fruits, and pieces of bark of a hard texture, mixed with some shells.

The presence of the shells in the shales, proves the access of the marine water; it is ordinarily accompanied with some fucoid plants and fishes. The fucoid plants are generally scarce in the coal slates, and the shells, though often represented by an immense number of individuals, are limited to a few species, which differ from those of the limestone, and seem to be of the kind generally living in the contact of the tides with the fresh water of the lakes or rivers. The slow propagation of those species lead us to suppose that they were distributed on a vast area, upon the beds where their remains are found. Therefore, if we can admit, that after the formation of each bed of coal, either the plants, or the animals that lived in the water which covered them, were of peculiar species, or at least that some species of plants or shells have either appeared for the first time in each bed of shale, or that identical species have been distributed in each of them in a different proportion, it is evident that the examination of the top or roof shales of the coal, and the study of their remains, whether plants

or shells, must give the most reliable character for the identification of the beds of coal.

There is no doubt, but after the formation of each bed of coal all the plants, and the animals belonging to it, have been destroyed, or at least removed far away. The vegetation of the marshes has been covered by thick bed of shales; the shales themselves, with their own inhabitants, have been again covered either by marine deposits of limestone, showing the remains of other peculiar species of organized beings, or by sandstone swept in by the high sea; and entirely destitute of animal remains. But even, when a bed of coal has again been formed over the marine shales, without any intermediate stratum, the formation of the fire-clay and the vegetation of the coal, both entirely barren of marine animals, both indicate a condition of things and a lapse of time which would, in all probability, have destroyed even their germs. If then, after the formation of a new bed of coal, and after an immense number of years, the downward movement of the surface brings again over it, the marine water and its inhabitants, is it rational to expect that this water will be still charged with the same species of animals as before, and that those animals will be distributed in the same proportion? Is it even rational to suppose, that all the circumstances producing the overflowing will be the same, with the same proportion in the quantity of marine water, the same chemical elements, the same depth, the same temperature, &c., &c. If there is only a small change of the elements dissolved in the water, (and truly, all the shales at different levels present different appearances,) it is certain that this change ought to have influenced the life, viz: the distribution of animals in the shales.

It is even so with the plants. The surface of a marsh having been overflowed, and its vegetation destroyed, we cannot but admit that if it begins again in a new sheet of water, and after a number of centuries, the distribution of this new vegetation will be somewhat different from the former. If there are no new species of plants, and certainly there ought to be some, at least some of the former plants have entirely disappeared and those which have been left are grouped in another proportion. Nature bears in one hand its scythe of death, and in the other its cup of life. At every geological change that closes the career of some living species, there appear some others, that were prepared for existence and begin their mission. And although

human life is limited to a day, in comparison with the innumerable ages of our world, we can sometimes observe those changes, and even analyze their causes. In the peat bogs of some high valleys of Switzerland, the bottom of the marshes is strewn with large trunks of oaks, and there the climate is so cold now, that the pines alone can grow. In Denmark this change of vegetation is also remarkably observed in deep bogs, which the proprietors find profitable to dry with hydraulic machines for the timber which they exhume. One of the most remark- of them has been explored and described, more than ten years ago, by the writer of this report* as its bottom, over the fire-clay, was first found four or five feet of very black peat, overlaid by a forest of pines, lying in the direction of the dip of the basin, viz: their roots against the sides. The diameter of many of their trunks was about one foot. Over the pines a bed of black peat, five to six feet thick, was still covered by an overthrown forest of white birch trees. A new bed of peat, six to eight feet thick, had buried it under its formation, and was overlaid by a third forest of oaks, of which the trunks, three to four feet in diameter, were so well preserved that they were sawed on the place and used for timber. Over this lay five to six feet more of peat, and the whole deposite was covered with humus, and a living forest of beach trees. The whole formation measured about thirty feet.

Along the shores of the Ohio and Mississippi river there has been deposited here and there, in different places, a quaternary formation remarkable for its thickness. Near Columbus, Kentucky, it elevates its white banks 160 feet above the level of the Mississippi river.† In its upper bed—a fine silicious loam—there is an abundance of shells, which, except one species, are still found living in the river below. This single species, either entirely disappeared or transported to some distant region, is sufficient to prove that if a new bed of loam was deposited now above the one mentioned, a close observer would already find a difference in their fossils. The lower bed of this quaternary deposit contains a quantity of leaves, already carbonized, the outlines of which are perfectly well preserved in the hardened white clay. Among them, the predominant species is an oak, (*quercus virens*), which, in our times, has its peculiar station along the shores of the ocean, and

*Explorations in the north of Europe, for the study of the coal formations. (Neuchatel, 1846.)

†First report on the Geological Survey of Kentucky.

scarcely grows out of the reach of marine water. There is in those remains of fossil plants very few of the species now living along the Mississippi and the Ohio rivers. A new deposit of leaves, now, would show a great difference between the vegetation of this last with the former one. Such difference in the recent formations may be observed in many places. From this it seems rational to admit, that two beds of coal, separated by various and sometimes thick strata of another nature, ought to present certain differences, in the remains preserved in their shale—some peculiar character which may enable a palæontologist to identify each of them, or to know their geological level at every place where it is possible to see them open for a careful examination.

Though the exposition of those principles is new, the best living geologists—Lyell, Brongnart, Burat, &c. &c.—have acknowledged their truth. For they have admitted that the palæontology of the shales would in time direct the identification of each bed of coal. M. de Humboldt, himself, says in his Cosmos: "That where several series of coal strata lie over one another, the genera and species of plants are not generally mixed, but arranged in a peculiar order for each bed."

The roof shales are subjected to some variation like the other formation, but they are rarely liable to modifications that can prevent their identification. Their thickness varies according to the depth of the water in which they are found. This depth of water, as we have before stated, would be nearly the same through the whole extent of a coal basin, if there had not happened some local depressions, caused either by volcanic commotions or by peculiar sinkings of the floating mass of vegetation. Those local depressions have caused the separation of a bed of coal into two or more branches, and sometimes its entire disappearance among high banks of black shales. Such cases are not very rare. Then the shales, though thick, being of the same age, and their inhabitants not having been subjected to any destructive change, they preserve identity in their fossil remains.

A short depression, or perhaps an accidental inundation of short duration, makes upon marshes the beginning of a formation of shales, which, if it is soon stopped by a new vegetation, produces in the bed of coal a separation or a clay parting. As these partings are formed upon the surface of a vegetable stratum, they ought to be generally

on a large scale, and follow the same rules as the shales. They may also thicken, or entirely disappear, or accidentally separate into two or three branches.

The shales may be wanting, either from erosion, or from the upheaval of a part of the surface above the water, or from the more active growth of the vegetable matter in a peculiar spot. The two last causes are scarcely observed: the first and more frequent one shall be mentioned again with the sandstone. Generally speaking, the absence of the shales is local, and ordinarily, even where they seem to be entirely wanting, if the mine be worked to any extent, they are discovered in some places.

4TH. THE LIMESTONE.

This formation can be regarded as a continuance, and sometimes as an equivalent, of the shales, since it is established only in an undisturbed sheet of deep marine water, by the continuous labor of marine animals, especially moluscs, and by the decomposition and accumulation of their remains. The essential reason of its formation, viz: deep, quiet, marine water, is nevertheless a cause of great variety—not in its chemical elements, perhaps, but in its persistency, its thickness, and its general distribution. It is often found in the Coal Measures in an unfinished state, in irregular masses, which can scarcely take the name of beds, so limited are they. For this reason the limestone, by its presence above a bed of coal, is scarcely a reliable guide for identification.

As long as the shales of the coal were deposited in low water, the influence of the sea, especially its currents, were scarcely appreciable. But in the limestone formation it is very visible indeed. The unequal distribution of the matter, and especially the remarkable erosions of the beds or isolated masses of it, are due to slow currents.

The limestone of the western coal-fields of America, contain a great amount of organic remains, plants, shells, or fishes. But the plants cannot give a reliable criterion for the geological level of each peculiar strata, since all the remains found till now are only broken, deformed, and undeterminable parts of stems, with few marine fucoids. The remains of shells and fishes would probably afford some reliable data for tracing the geological level of the beds of limestone. They are only too numerous in their species, and have never been subjected to a

careful study. The animals of the limestone belong, evidently, to the sea, and are brought in with it. In a change of level they are destroyed as individuals, not as species. Nevertheless, after a length of time, a new invasion of the sea ought to bring with it, upon the coal-fields, other species, since its neighboring sea and its inhabitants ought to have been subjected to changes.

Thick beds of limestone, interposed in many places between beds of coal and shales, offer the most certain indications of the slowness of the oscillations in the level of the coal-fields at the time of their formation. Not only the great number of species—the myriads of animals of which the remains have been literally heaped together—but the introduction of madrepores, and their constructions, marked in the limestone strata, call for an inconceivable length of time.

5TH. THE SANDSTONE.

In its general appearance, thickness, and composition, this formation is the most unreliable of all. A substance, of which the elements have been transported and intermixed by currents, can never be an homogeneous one, especially when these currents are abnormal, the result of a cataclysm, and have exercised their action over a very extended surface, following numerous diversified phenomena. The movements of the waters, which have brought and deposited the sand, are made appreciable not only by the nature of the strata, but by traces of remarkable erosions. In some places the immediate contact of the sandstone with the coal cannot be explained but by an erosion of the beds of shales and limestones which were extended upon it. Even the coal has been sometimes swept away, then bruised, and deposited again with the sand by the energetic action of those turbulent waters. Beds of hard sandstone are so blackened by the broken fragments of coal and plants, with which they are intermixed, that they cannot be used for building purposes. No wonder that such mighty currents have dragged with them, and buried under heaps of sand, large trunks of trees, torn from the dry land of the shores, or from the forests of the marshes; or that they sometimes entombed in their ponderous deposits parts of forests, which are still now found standing and petrified like the pillars of some old Babylon of trees.

From this we may conclude, that the remains of vegetation found in the beds of sandstone cannot show, generally speaking, their geologi-

cal level. Beds of sandstone appear, particularly marked with the remains of broken plants. It may be that by a mighty cataclysm, immense marshes, covered with trees, have been entirely swept over, and that their remains, bruised and ground by a prolonged action of the waves, have eventually been carried and deposited over the whole area of the basin. It may be, also, that the large trunks, either standing or heaped up together, in some parts of the coal-fields, where they are found now in great abundance, bear evidence of a general and remarkable cataclysm; and that they may thus indicate a constant geological level in their position. Some incomplete observations tend to confirm this supposition, but they are still too scanty, and need to be pursued over a wide area.

It is scarcely necessary to explain why, in the beds of sandstone, the trunks of trees are mostly petrified, preserving their general outline, and not flattened as in the coal. Not only the sand is too porous a matter to prevent entirely the access of the air, but its mineral elements have exerted a constant action on the woody matter, and destroyed it entirely, or taken its place, leaving only its outline carved like a mould in the stone. Or they have transformed it to some stony substance—either silex or carbonate of lime and spar—preserving thus partially, not only the external features, but even the internal structure of the wood, to the most delicate fibres and vessels.

It has been asked many times, why, since the sandstone is a marine formation, it does not contain any shells, any remains of marine animals? Indeed, this question would be unanswerable if we were to suppose that the materials carried by the sea had formed its bottom. This supposition is not inadmissible. Though the depression of an immense plain near the sea shores would take it below the level of the water, it could not raise the bottom of the sea, and spread its sand over it. But every one knows that the sea shores are every where bordered by hills of sand, sometimes several hundred feet high, and extening many miles, like huge inland waves. Near the mouth of the Elbe and of the Rhine, those hills penetrate the country for hundreds of miles. The sand of which they are composed—coarse or fine—is sometimes mixed with gravel, but contains no shells or animal remains. Such sand hills have probably furnished the materials for the sandstones of the Coal Measures; at least this is to me the only satisfactory explanation of their formation and composition.

The other rocks of the Coal Measures, like the deposits of iron, under their different forms and compounds, are purely local, and have no relation to our subject, viz: the identification of coal veins by palæontology. The discussion of their formation and distribution would be out of place here.

To conclude these preliminary remarks, we need only expose, in a few words, the general rules which are drawn from them:

1st. The black shales, immediately resting upon a bed of coal, viz: the roof shales, furnish, by their remains of fossil plants, shells, and fishes, the most reliable indications for the identification of their geological level.

2d. The remains of plants give for this the best characters, since the vegetation of the coal beds was more generally and uniformly distributed on large surfaces, and since the plants, by their progressive modifications, are subject to atmospherical influence, and also to the chemical changes of the water.

3d. The geological distribution of the plants or shells cannot be modified in a sudden and striking manner at each change of level. Therefore, the presence or absence of a species in the shales may be accidental, and cannot be a conclusive evidence of a change of level, except after a long and careful examination over a wide area. The grouping of fossil species in the shales and its variations, afford a more reliable indication than the presence or absence of a single species.

This sufficiently shows the difficulty of the work of identification, in a country where a small number of beds of coal have been opened and worked, and where palæontological researches have been scarcely begun; in fact, this report is only the introduction to an important work, which ought to be pursued with interest by every true geologist, for the history and perfect acquaintance, not only of the coal fields in their general features, but of every bed of coal in particular. But it must be said, that a collection of specimens, made only for the beauty and the great number of specimens for show, is of little use. It ought to be made with a careful record of the place, and, if possible, of the true geological level in which the fossil remains are found. And thus it may, by and by, help to solve some of the most interesting problems of the formation of the coal, viz:

Is there any true marine formation of the coal? From long explorations pursued in Europe and in America, the writer says, contrary to

many assertions, that there does not exist a bed of true marine peat, viz: peat formed entirely of fucoides and marine plants; and that he has never seen a piece of coal with evident marks of marine origin.

Have all our American coal-fields been formed in a continuous basin, or is there any local one with an appreciable difference in the flora and fauna of the shales?

Is there any trace of a permanent current of fresh water, of some river having flowed either through the coal-fields during some time of their formation, or in their vicinity?

Were the coal-fields the first land surface protruded like an island from the sea, or were they true marshes, low shores of a continent, of which the outlines had been already elevated above the ocean?

These are not the only questions that are to be answered. Beside the mere practical advantage to be derived from the palæontology of coal, there is the nature of the vegetation, its relation to the atmospherical phenomena of the epoch, its comparison with the flora of our peat formations, and also with the coal flora of other continents, and many other subjects, which open up to the geologist a most interesting field for the exercise of the mind.

Horizontal exposition of the different coal beds examined in the western coal field of Kentucky.

COAL No. 12.	Airdrie 2 ft. 8 in rash 1.4 coal.	A. Town's rash coal, ft?	Near Curdsville, 6 in. rash coal.	McNary's 4 ft. rash coal.	Peaks of Otter, 4 ft. rash coal.	Pigeon Run, 2 ft. rash coal.	
COAL No. 11.	Airdrie 6 ft. coal.	A. Town's 6 ft. coal.	Near Curdsville, 4 ft. coal	McNary's 7 ft. coal.	B. Sisk, 6 feet.	Pigeon Run, 8 ft.	Providence, 6 ft.
COAL No. 10.		Seen	only	at	Shawnee	town.	
COAL No. 9.	Airdrie 4½ feet.	A Town's 5 feet.		McNary's 4½ feet.	Gamblin, 4½ feet.	Jakefield, 4½ feet.	Captain Wings, 2 ft.
COAL No. 8.		Not	seen.				
COAL No. 7.		A. Town's black band coal.					
COAL No. 6.							
COAL No. 5.		Not	seen.				
COAL No. 4.		Not	seen.				
COAL No. 3.							
COAL No. 2.							
COAL No. 1 b.	Bell 5 ft.	Cook 5 ft.	Casey 4 ft.	Old distillery 3 ft?	Union Co., 3 feet.	Hawesville, 4 ft.	Breckinridge, 3 ft.

Horizontal exposition of the different coal beds examined in the western coal field of Kentucky.

COAL No. 12.							
COAL No. 11.	Watson's, 6 feet.	Thompson 6 ft.	Arnold's, 8 ft.	Miller's, 6 ft.	Bonharbor, 5 ft.	Curlew, 3 ft.	Mulford, 3 ft.
COAL No. 10.							
COAL No. 9.	Isaac Luce's, 4 ft.	Hartford, 2 ft.	Lewisport, 4 ft.	Henderson, 4.3		Curlew, 5 ft.	Mulford, 5 ft.
COAL No. 8.							
COAL No. 7.							
COAL No. 6.		Barrett's, 4 ft.					Mulford, 3 ft.
COAL No. 5.							
COAL No. 4.							
COAL No. 3.							Mulford, 2½ ft.
COAL No. 2.							Mulford, 1 ft.
COAL No. 1 b.							Mulford, 2½ ft.

Examination of some veins in the Western Coal-fields of Kentucky, in relation to their palæontological characters.

As during the time of our explorations we passed over different parts of the country, with a continuous change of level, any description of the veins of coal, in the order in which they came under our observation, would be not only an arduous task, full of useless repetitions, but, by constantly transporting the reader to a different geological level, would confuse his mind about his exact position. The better plan, therefore, is to admit as correct a vertical section of the western coal-fields, and, beginning from the bottom of the measures, take each bed in the order of formation; then, describing the general characters of each of those beds, and mentioning afterwards all the places where the same coal has come under our examination, with the local and peculiar differences of each. In this way all will be clear, and a single glance at the horizontal section No. 1, will show, at once, the localities, with their true geological level, and suggest, at the same time, to the reader, precise conclusions with regard to the probable position of other beds of coal, and enable him to make other deductions for the greater certainty of future researches.

No. 1. Vertical diagram of your first report, from Anvil Rock down to Battery Rock, is certainly the best that can be made, and, with some local changes, it will prove reliable in all the extent of the western coal-fields of Kentucky. Following your suggestions, we will admit the nomenclature of the veins of it, as follows:

Beginning at the base of the measures, and omitting Battery-rock coal—a view which is scarcely developed any where in Kentucky—our No. 1 coal takes the place of both Cook coal, and 7th Bell's coal, indicating their probable relative position by A and B—No. 1, B, being the Bell's coal. The reason why both those veins are united in the same number, will be apparent hereafter. Our No. 2 is a thin coal, marked on the diagram between two shales with iron stone. No. 3 is the 6th, or Ice-house coal of the diagram. No. 4 the Curlew coal. No. 5 four foot bed. No. 6, the little vein. No. 7, a thin coal above it. No. 8, Well coal. No. 9, 3d or five-foot Mulford coal. No. 10, 2d or middle coal. No. 11, the first coal under Anvil Rock. No. 12 the true first bed below Anvil Rock, in Hopkins and Muhlenburg counties, omitted in the diagram, because it is scarcely developed in Union county.

Battery-rock coal. Though in the eastern coal-fields some workable beds of coal have been found, not only in and below the conglomerates, but even in the red sandstone, there is not, apparently, in the western coal-fields of Kentucky, a true bed of coal formed in this position. Opposite Caseyville, below the conglomerate rocks, hanging over the landing on the Illinois side, there is a thin black shale, itermixed with thin layers of coaly matter. This shale does not contain any fossils. The same shale has been reached at Caseyville, by boring a well below the conglomerates; but it does not contain any trace of coal, neither did the shales, though of soft texture and nearly black, show any remains of fossils of any kind. In Pennsylvania, the shales of the bituminous coal, or of the anthracite, exposed below the conglomerates, contain specimens of large pieces of *Calamites* and *Lepidodendron.*

No. 1 *Coal.* Above the conglomerates, and often reposing on them, there is a thick formation of black shales, varying in thickness from 20 to 70 feet, or more. It sometimes contains two beds of coal, one well developed, from 3 to 6 feet thick, and a thin one below. Generally the position of the large bed No. 1, B, depends on the thickness of the shales. From the topographical observations it ought to be 70 feet above No. 1, A. But the palæontology of the opened coal, topographically indicated as No. 1, A, having proved exactly the same as those indicated as No. 1, B, the only conclusion to which I can come is this, either in the western coal-fields of Kentucky there is a single bed of coal, formed in the shales above the conglomerates, and then, No. 1, A, and No. 1, B, are the same; (this is my settled opinion;) or the palæontological characters of the shales are the same in their whole thickness, which is scarcely possible. In Pennsylvania, where the bed of shales contains two, and sometimes three, seams of coal, the shales of each peculiar bed of coal present a different appearance, and different fossil plants are found in connection with them. These fossil plants are especially the prints of the bark of large trees, *Sigillaria*, *Calamites*, especially *Lepidodendron*, (pl. 7, figs. 1, 4, 10); the cones of these last trees, *Lepidostrobi*, (pl. 7, fig. 3;) many other fruits of the genera *Trigonocarpon*, *Cardiocarpon*, and *Carpolithes*, (pl. 7, figs. 5 to 9.) These fruits are generally compressed, resembling flattened al-

monds, peanuts, or peas.* The ferns imbedded in the shales are generally of the largest species. The genus *Sphenopteris*, (pl. 6, fig. 1,) is represented in this low coal by most of its species, which are scarcely found above it, and some large *Tecopteris*, especially *Tecopteris lonchitica*, (pl. 6, fig. 3,) belong also to this bed only. *Neuropteris hersuta*, &c., (pl. 6, fig. 4,) is generally found in the shales; but this plant appears in the whole thickness of the Coal Measures, as well in Europe as in America. We mention it only to prevent mistaking it as the characteristic plant of a certain level, or admitting, for peculiar species, the numerous forms of its curious leaves scarcely ever found attached to the stems. These leaves are ordinarily lanceolate-oval, with a heart-shaped base, and have two small round kidney-shaped leaflets attached at its base, but sometimes they become either large, and nearly round, (*Cyclopteris*,) or narrow lance-shaped, or palmately cut in two or three linear divisions. Since its surface is ordinarily strewn with scattered hairs, all these forms can easily be referred to their species.

It has been asserted by many that *Stigma coides*, (pl. 7, figs. 2 and 2a,) is a plant, or rather a root, found in the fire-clay only, where it has sprung, supporting the trees that have formed the coal above it. This is a great mistake, which would be corrected by a single look at our bed, No. 1 coal, where the coal itself, and the shales above it, contain most abundant specimens of those *Stigmaria*.

A remarkable peculiarity of the black shales of this coal is, that they contain, also, in immense numbers, the remains of a single species of shell, a small oval *Lingula* (*Lingula umbonata*,) which, by its appearance, indicates the first traces of the marine element in the shales. A few badly decayed leaves of ferns, and the *Lepidostrobi*, (pl. 7, figs. 3, 5, 6,) are found on the same shales with the shells, evidently showing that the vegetation had not entirely disappeared when the marine water began to cover the marshes. This small *Lingula*, always the only shell found at the same geological level in the shales, not only in all the beds of the first coal in western Kentucky, but in Ohio, at Nelsonville and other places; in Virginia, at great Kanawha Salines; in Pennsylvania, at Rochester, Johnstown, &c.; indicates

*This description is given only to facilitate the comprehension, but not at all as a scientific and real one. The fruits of the coal, though their appearance may sometimes be the same, do not have, in reality, the slightest analogy with those of our time.

the vast range of distribution of this species, and this peculiarity of a vein of coal preserving, in its shales, a palæontological identity, for more than five hundred miles distance in a direct line.

Bell's mine, Crittenden county, is extensively worked. This bed has a mean thickness of five feet. The coal has ordinarily one or two inches of cannel at the top of the bed. It is mostly covered by thick sandstone shales, full of leaves of *Stigmaria*, preserved in their natural round or cylindrical form, and scarcely flattened. These sandstone shales are not the original roof shales, which are generally wanting here, but they have accidentally taken their place, after denudation of the first roof. The same case is observable at Minersville, Pa., in the corresponding bed of anthracite, viz: the second bed above the conglomerates. The true roof shales are seen in some part of the mines at Bell's, and contain *Lingula umbonata* in abundance. Near the base of the coal there is a thin bed of rash-coal, containing well preserved specimens of *Lepidodendron*, *Sigillaria*, and *Stigmaria*. This rash-coal is certainly a peculiar and reliable character, and has been seen at all the places where we had opportunity to examine No. 1 coal—always containing laminated bark of *Lepidodedron* and *Calamites*. It is also well marked in the coal fields of Ohio and Pennsylvania, at the same geological level.

Half a mile southeast of Bell's we were shown the old opening of a vein previously worked, but now abandoned. They called it Cook's vein, and said that it was at a different level from Bell's, viz: about 70 feet below. The palæontological remains of the shales prove that this supposition is a mistake. The roof-shales of this coal are the same thick sandstone shales, full of *Stigmaria*, as at Bell's, and the bottom has the rash-coal, with the *Lepidodendron*. We did not explore the interior of this vein, which is full of water, but the characters were evident enough in the shales heaped at its mouth.

Between Bell's and Tradewater river, the same vein has been opened and worked, and there also we found the sandstone shales, with round *Stigmaria*, and the rash coal with *Lepidodendron*.

Casey's mine, on the west side of Tradewater river, has its roof shales more developed than Bell's, and shows, in their composition, all the essential characters of the coal on this level. The black slates of the coal contain not only a great abundance of *Lingula umbonata*, but

also the fruits of *Lepidodendron*, viz: *Lepidostrobus*, and its detached leaves *Lepidophyllum*. The rash coal at the bottom has the *Lepidodendron*, *Stigmaria*, and *Calamites* in abundance, and the coal itself is topped as at Bell's, by one or two inches of cannel. Moreover, at some places in the mines the black shale is wanting, and its place is taken by the sandstone shales with round leaves of *Stigmaria*. The distance between the two mines of Casey's and Bell's being short, a few miles only—the exact resemblance of the shales and of the fossil remains, is not a remarkable coincidence; but it is otherwise when we compare the fossils with those found at the same geological level in far distant localities. We have seen that the *Lingula* abounds in many places in the low coal of Ohio and Pennsylvania. The *Lepidostrobus* has, till now, never been found but in the corresponding low coal at Johnstown, at the base of Portage Railroad, in the bituminous coal-fields of Pennsylvania, and at Wilkesbarre, in the anthracite basin. The presence of those fruits or cones, in the same shales as the *Lingula*, evidently shows that they were the last remains of the vegetation of this coal, and that they had been detached from some trees still standing above the shallow water, and living in it when the vegetation of the surface had already disappeared.

Old Distillery coal, just above Caseyville, has its place at the same level, evidently marked by the abundance of *Lepidodendron* in the rash coal of the bottom, and by the *Lingula* and *Stigmaria* in the shales of the roof. That there may be near by the same place, a shaft to a lower bed of coal, is possible. But we did not see it, and the position of this coal of the Old Distillery, would scarcely lead to the supposition of another bed of coal below it.

A recently opened vein, one and a half miles north of Caseyville, on the property of the Kentucky Coal Company, though supposed to be also at a lower level, afforded another favorable opportunity of testing the value of a palæontological identification. We found this coal covered with a shaly sandstone, full of *Stigmaria*, and by three to four inches of black shales, with *Lepidodendron* and *Lepidostrobus*. Its thickness is only two feet six inches. It has some cannel at its top, and a rashy bottom, with fine remains of *Lepidodendron*, *Calamites* and *Stigmaria*.

Opposite Caseyville, on the Illinois side of the Ohio river, there is a bed of coal belonging to Dr. Long, which, following topographical indications, is placed below the conglomerates, and indicated as Battery-rock coal. This coal is, without doubt, above the conglomerates, and from the plants and fossil remains of the roof shales, is the same as our No. 1. The appearance of the shales is, however, different. The marine element being less predominent, the shales grayish colored, and full of well preserved remains of plants. The whole flora of the low coal is there—*Stigmaria*, *Lepidodendron*, *Lepidostrobus*, and many other fruits, with large leaves of ferns, especially *Pecopteris lonchitica*. As the bed is not worked, and the shales are very brittle, we had to study them on the place, and it was not possible to collect good specimens, except a very large and well preserved root of *Stigmaria*.

At Union mines, Crittenden county, twenty miles below Caseyville, the characteristic fossils of No. 1 coal, are still more numerous, and in a better state of preservation. The shales there are thick and well developed. First, the sandstone shales, with *Stigmaria;* then, in some places above the coal, the black shales, with *Lepidostrobus* and the *Lingula;* and still oftener, the gray soft shales, full of plants, especially *Pecopteris lonchitica* and *Sphenopteris*. The coal itself is ordinarily topped by a few inches of cannel, and its bottom has always the rash coal, with the same remains of plants, as we have enumerated before. The shales at Union mine would have afforded a good opportunity for collecting and studying a great number of species of fossil plants, had they not been softened by rain, and our specimens nearly all broken by transportation. The species which were left entire enough to be just distinguishable, are the following: 1. *Alethopteris sinuata, Brg't.* 2. *Alethopteris lonchitica, Brg't.* 3. *Sphenopteris tridactilites, Brg't.* 4. *Spenopteris intermedia, Lsq'x.* 5. *Asterophillites avalis, Lsq'x.* 6. *Calamites Suckovii, Brg't.* 7. *Lepidodendron politum, Sp. Nov.* 8. Two other species of *Lepidodendron*, (broken.) 9. *Lepidophloios rugosus, Lsq'x.* 10. *Lycopodites Sticlerianus, Gopp ?*

Hawesville coal. Passing to the eastern part of the western coal-fields of Kentucky, we had first a good opportunity of exploring the lowest bed of coal at Hawesville, Hancock county, where it is extensively worked. The coal, three feet ten inches to four feet thick, is cannel at the top, and reposes upon six inches of rash coal, containing

still the same plants—*Lepidodendron*, *Calamites*, and *Stigmaria*. The black shales above the coal are full of *Lingula umbonata*, and have also some remains of broken plants, especially *Lepidostrobus*, of which we obtained good specimens at Mayo's vein. In connection with this bed, and above it, are also the gray shales, with a few fern leaves of the same species, as at Union mines.

About seventy feet above the main coal at Hawesville, there is, following the assertions of Mr. Taylor, director of the mines, a bed of rash coal, with large stems of *Calamites* and *Lepidodendron*. It ought to be separated from the main coal by thirty feet of sandstone shales, and thirty feet of black shales, containing the above mentioned fossil shells and plants. Does this rash coal, if its position is exactly marked, indicate the place of another bed of coal, or is it still a continuance of the interrupted black shales which, at some places, are seventy feet thick? Or, perhaps, has it been displaced by one of the numerous faults which break the level of the Hawesville vein? These are questions that remain to be solved.

Breckinridge coal The appearance and chemical composition of this coal would indicate, for this vein, a far different level. Nevertheless, a short examination of the fossil plants of the shales, suffices to ascertain that its geological position is the same as that of the Hawesville. The coal, twenty-eight to thirty inches thick, is entirely cannel, and full of stems and leaves of *Stigmaria*, the outlines of which have been preserved by sulphuret of iron. Under it the rash coal is seen, with its *Lepidodendron*, *Calamites*, and *Stigmaria*, and it is topped by a heavy bed of black bituminous shales, with *Lingula umbonata*, and some specimens of decayed fern leaves. As it generally happens, in very bituminous shales, the plants are scarcely preserved. Their outline only is indicated here and there, but with such indistinctness that they cannot be exactly determined; the coal itself, however, has preserved beautiful prints of *Lepidodendron*. We have previously mentioned that the *Stigmaria* have probably been plants of a strong texture —a kind of creeping roots, especially active in the preparation of the fire-clay. If this were so, they could not contain much bitumen, and yet they are found in abundance, and well preserved in outlines, in the richest oil producing coal of Kentucky, and perhaps of the United States. Since it is proved that the *Stigmaria* were of the nature of

roots or, as I think, were creeping rootstocks, producing trees under favorable circumstances, their presence in a bed of coal, where they could not creep, as in the water, and where their direction was necessarily changed by many circumstances, indicates that there were plenty of trees living at the time of the formation of this coal. If the trees had had the same hardened silicious bark as the *Stigmaria*, their outline would also have been preserved; but being especially of coniferous or resinous species, they have been entirely transformed into coal. This shows that the cannel coal results from the abundance of some kinds of trees, especially *Sigillaria* and *Lepidodendron*, or perhaps *Lepidodendron* only. Moreover, the chemical composition of some plants, especially of roots, depends on the place where they grow; on the water which they absorb. The needles or leaves of coniferous trees, for example, living on the limestone, contain only two per cent. of silica, when the same species, living on silicious ground, have as much as five to six per cent. of it. We must therefore suppose, that according to their habitation, the *Stigmaria* would necessarily show a difference in their composition.

The analysis of the Breckinridge coal proves, nevertheless, that though it has been formed of resinous trees, since it contains sixty-three per cent. of volatile matter, there were abundantly mixed with it plants highly charged with siliceous matter—the *Stigmaria* certainly—for it gives by combustion as much as eight per cent. of ashes. The main coal of the Shawneetown Company, at quite a different level, is also very bituminous, does not show any trace of *Stigmaria*, and has only one half per cent. of ashes.

If it had been possible to see at once, and opened, all the beds of the Coal Measures in successive order, the true characteristic fossils of every one of them could perhaps have been examined and described; but in a level country, where the highest hills do not exceed three hundred feet, such an examination is no where possible. In both places where, according to your directions, we could expect to see a succession of coal beds, at different levels, viz; at Shawneetown, and at the Saline Mining Company's works, in Illinois, we had good opportunities to study the fossils of vein Nos. 9, and 11. At the Kentucky Coal Company mines, we saw open one bed still lower—No. 6, or Little vein. But we did not find any place where beds 2, 3, 4, 5, 7, and 8, were opened,

and their geological level fixed with such certainty that we could take them as a point of comparison for the examination of others.

Coal No. 2. We have not yet seen this bed satisfactorily in place in Western Kentucky; in fact, this coal may be united in the west with No. 1, B, since I found at Beaver, at Johnstown, at Nelsonsville, and other places, a coal which I think will prove the equivalent of Lesley's cannel coal C, which contains apparently the same *Lingula umbonata* as was found in the shales over No. 1, B, of Union county. There appears to be a gradual diminution of the space between this cannel bed C, of Pennsylvania, and the great bed below it going west; for, though at some places in that state the distance is seventy feet, at Zanesville, Ohio, it is only twelve feet; at Hopwelltown, Ohio, five feet; and at Nelsonsville, Ohio, only one foot, and sometimes only four inches. Therefore, it would not be very remarkable if, in Kentucky, it should be united with coal No. 1, B. Moreover, this bed is often wanting either in its separate state or in conjunction with No. 1, B. In the last case, the shales of the coal No. 1, B, are less bituminous, grayish, full of plants only, and without shells. At the Breckinridge mines, it seems to occupy the whole place of No. 1, B, and has influenced its transformation into cannel.

Coal No. 3. Near Mulford's mines we were shown, as being probably the Ice-house coal, a scarcely opened bed, of which the remarkably hard, greyish colored shales were marked with well preserved stems of ferns, especially of *Neuropteris hirsuta*, (pl. 6, fig. 4.) Being unable to see more of this coal than a few shales, and being uncertain as to its true level, we could make no characteristic and reliable description of it. But judging from a palæontological point of view, No. 3 coal, seen at Hawesville, is not the same as the one mentioned at Mulford, as the probable Ice-house coal. It is much more likely referred to coal D, of Lesley's manual, which is extensively worked at Zanesville, (two to four feet thick,) where its shales are full of shells, especially of large *Productus* and *Spirifer*. I should not have a doubt of their being coeval if it was not for the absence of limestone above this coal at Zanesville, where the eight feet shales are covered with forty feet of sandstone. But the limestone of this coal is a local formation. In his general description of the lower coals, Mr. Lesley indicates a limestone E, separated from coal D by fifty feet shales. And even at

Zanesville, there is above this coal, on the top of Putnam hills, a thin fossiliferous bed of limestone. As for the value of the limestone as a character for identification of the coal beds, a look at both vertical sections, No. 1 and No. 2, of the first report of the Geological Survey of Kentucky, will show its deficiency. The bed of limestone, only four feet thick, of the first diagram, is represented in the second by a heavy formation of two beds of limestone, the one thirty-three feet, and the other eight feet thick, separated by five feet of shales.

This 3rd coal at Hawesville is about two hundred and ten feet above No. 1, B, the main coal at this place. It has been opened and worked for a time and is now abandoned—its thickness being only twenty-two inches. It is covered by a black shale one foot thick, which decomposes in powder under the atmospheric action, and shows no trace of fossils, either shells or plants. Upon the shales there lies another soft and still looser sandy, micaceous, buff-colored shale, insensibly passing into limestone, and full of large *Productus* and *Spirifer*. This shale is like a rotten limestone, and the fossils that it contains, though badly preserved, are easily separated from it. It is overtopped by a bed of limestone.

Coal No. 4. We had no better opportunity to study this coal than the former, in the coal-fields of western Kentucky. The coal with two clay partings, that is referred by order of superposition to this geological horizon in Curlew hill, with limestone at a distance of fifteen feet beneath it, I had no opportunity of examining, as the old opening into this coal was entirely filled up, and the roof shales quite inaccessible.

At Giger's hill, Union county, we examined a coal three feet thick, with two clay-partings, covered with a bed of five to six feet shales, differently colored, grey or black, becoming soft and finely grained in the proximity of the coal, and entirely covered with prints of *Neuropteris flexuosa*, Brt., (pl. 6, fig. 2.) This species, like *Neuropteris hirsuta*, Lsq'x., is generally too far distributed in the whole thickness of the Coal Measures to afford, by its presence alone, a true reliable character for the geological position of a vein. Though it is most abundant in the Pomeroy coal of Ohio, which would correspond with our coal No. 4, I have found it also in the barren measures between Athens and Marietta, Ohio, above the Pittsburg vein, and even in the shales of

a higher level near Greensburg, Penn. In Posey county Indiana, there is a bed of barren shales, abundantly covered with this same plant, which is also in a much higher geological position than the coal No. 4. As there is then some evidence going to show that the coal of Giger's hill occupies a higher position in the Coal Measures, we must leave this for the present undecided, until further data are collected.

The 4th coal, which has the same geological horizon as the Pomeroy coal of Ohio, and the Gates and Salem vein of Pennsylvania, is generally covered with greyish-black, hard, somewhat micaceous shales, in which the greatest number of species of fossil plants are preserved. We have already mentioned *Neuropteris flexuosa*, which is there in the greatest abundance, but it is necessary to name some other species, more or less generally distributed in this bed, and which may serve to its identification in different places of the coal-fields: 1st. *Pinnularia*—a large confervoid plant, resembling a much branched thread-like root. 2nd. A brownish yellow fucoid, of which fragments only are found, detaching easily from the stone, like a thin skin—these are both found especially in the Ohio coal-fields, at Pomeroy and Federal creek. 3rd. *Asterophillites*—plants resembling our *Horsetails* (*Equisetacea*,) with long whorled branches, bearing, at short and equal distances, whorls of short narrow linear leaves. 4th. *Sphenophyllum* and *Annularia*—floating plants, with whorls of flattened, entire or diversely cut leaflets. 5th. Many species of *Neuropteris* and *Pecopteris*, especially *Neuropteris fimbriata*, Lsq'x., and *Pecopteris arborescens*, Brt. 6th. *Flabellaria boracifolia*, Sternb—a plant which, by its long ribbon-like leaves, closely and very finely ribbed, embracing the stem at the base, bears a strong likeness to a species of palm. The stem is seldom found—I obtained this year, for the first time, a specimen of it, at Salem vein, of Port-carbon, near Pottsville, Penn.; but the leaves are most abundant in all the shales of this 4th coal, and may be considered a true characteristic of it. In the lower beds I have seen some fragments of another larger species, but none of this. At Giger's we did not find any, and the only species discovered there, except *Neuropteris flexuosa*, is another fine *Neuropteris*, probably referrable to *Neuropteris conjugata*, Gopp. This vein has, also, some species of *Calamites*, *Sigillaria*, and *Stigmaria* in its shales, but I never saw in them any *Lepidondendron* nor *Lepidostrobus*.

The abundance of fossil plants preserved in this 4th coal, is truly astonishing. At Pomeroy the roof is in some places totally covered with those remains. In some pieces of shales, less than half a foot square, taken from Salem vein, at Pottsville, I have counted fifteen to twenty species. It might appear extraordinary that Pomeroy coal of Ohio, and Salem vein, of Pennsylvania, the highest bed of the anthracite coal basin, ought to be referred to the same geological level; but if we believe palæontological evidence, we cannot come to another conclusion, most of the fossil plants being of the same species, and these species being found no where else. Besides, its palæontological characters, No. 4 coal is marked by its one or two clay partings, which eastwards, become very thick, and form true strata, separating the vein into two or three, and also by the superposition of heavy beds of sandstone.

Coal No. 5, has not been satisfactorily seen, as the old opening, like that of No. 4, is now entirely filled, and the shales that were taken out not only disintegrated, but mixed up with those of No. 6 coal lying above.

On section 24, T. 3, R. 2 W., about a mile southeast of the Mulford's mines, Mr. Cox examined a coal, and obtained some fossil ferns from its shale roof. These I find to be prints of *Neuropteris teneuifolia, Brg't.*, a species so very like *Neuropteris flexuosa, Br't.*, (Pl. 6, fig. 2,) that is unnecessary to give a drawiug of it. It differs only in the thinness of the veinlets, scarcely visible to the naked eye. This coal vein is cannel at the top, passing insensibly into four feet of black shales, in which the above plants were found. These species of ferns remind me of those which occur in the roof of a bed of anthracite coal, which I examined in Shamokin Valley, Pennsylvania.

Coal No. 6, has been opened at Mulford's mines, Union county, Kentucky, where we first examined it, and where it is called Little vein. The coal is somewhat rashy, mixed with an abundance of pieces of charcoal, and colored brown with oxide of iron. It has above it a thin layer of black brittle slates, with remains of stems covered by arenaceous, micaceous, yellow, or chocolate colored shales, marked with innumerable remains of much broken, nearly ground up plants. In ascending the bed of shales, they became whitish, passing insensibly into sandstone shales, and the remains of plants more and more pul-

verized, cover them in an indistinct mass. Though I cannot name any peculiar species, in connection with this bed of coal, since all the examined remains were too much broken to be recognizable, the general appearance of the shales is peculiar enough to serve as a reliable character. We knew this coal again at first sight when we came to it with Mr. Cox, two and an half miles from Hartford, Ohio county, Kentucky, where it is worked near the Owensboro' road; and still again, lately, while on a tour of exploration in the southern part of the coal basin of Ohio, I knew it at once when I saw it at Steiger's vein, near Athens, and from the inspection of the shales alone, fixed at once its true geological level.

Coal No. 7, is a thin bed, which we did not see any where in the western coal-fields of Kentucky, but of which we examined the shales exposed in a rivulet on the Saline Coal Company's property, in Illinois. These shales contain a few shells, but particularly some very small scales and teeth of fishes. These teeth are sharp, straight, and of a different form from those found in the beds above. I thought at first that it was not worth while mentioning this coal, since it is generally very thin—for it has been passed through by a shaft at Mulford's, and has been found to be there about thirty inches thick; at Holloway's boring, near Henderson, its place is occupied by a black shale, with only some trace of coal; and in the Illinois coal-fields, it is only a few inches thick. But though not valuable in a material point of view, this bed becomes important by its characteristic fossils, and its geological position. Being lately at Athens, on an exploring tour through the coal-fields of southern Ohio, I had the opportunity to survey, on the property of Horace Willson, Esq., a bed of shales which was thought to contain a vein of coal. I collected there teeth and scales of fishes, and after a comparative examination, I found them to be of the same species as those which we collected with Mr. E. T. Cox on the Saline Company's property. This bed of shales near Athens, Ohio, contains only a few inches coal, and its position is about one hundred feet below the Pittsburg coal, which is worked somewhat higher in the hills. The identity of both these beds of western Kentucky and Ohio veins, as we said before, is of great importance, since it enables us to point out, with some accuracy, the place that the Pittsburg coal occupies in the western coal-fields. This place, as we

will show more evidently in the examination of coal No. 9, is very probably the one occupied by the following No. 8, or Well coal.

Coal No. 8. This coal has been crossed in the shaft at Mulford's, where it is two feet six inches thick. But we could not see it, nor examine any of its shales, as the shaft was not accessible. It has been passed through, also, at the Holloway's boring, and has been mentioned in the survey of the Saline Company, always with the same thickness. This indicates a reliable and extensively formed vein of coal, and for this reason, it is especially to be regretted that we did not find a single opportunity of comparing the fossils of its shales with those of the great Pittsburg coal. The characteristic plants of this remarkable bed are not well defined. The shales immediately above the coal, are very black, bituminous, and covered with stems of ferns without leaves; these stems are very numerous, and sometimes heaped together in a confused mass. The vein of coal is divided into two, (rarely three strata,) by clay partings, or shales of various thickness, and it is only above its upper roof shales that some leaves of ferns, especially of *Neuropteris hirsuta*, *Lesq'x.*, and *Pecopteris heterophylla*, *Brg't.*, are preserved in a reddish ferruginous hard shale.

It may appear strange that we can refer to a coal, generally acknowleged as the thickest and most extensive one, such a thin bed as our No. 8; but, if we follow the Pittsburg coal from its eastern limits, where it attains its greatest thickness, we see it gradually thinning westward, in a remarkably uniform manner. In the Cumberland basin of Pennsylvania it is fourteen feet thick; in Elk Lick township, Sommerset county, eleven feet; in Legonnier valley, Fayette county, and at Pittsburg, nine feet;* at Wheeling, it is already reduced to a little more than six feet, viz: coal one foot, shales one foot, coal five feet five inches; and at Athens, Ohio, to about five feet, viz: two feet five inches coal, one foot and an half fire-clay or shales, and three feet coal. From Cumberland, Penn., to Athens, Ohio, the distance in a direct line is about one hundred and eighty miles, and from Athens to Mulford's, in western Kentucky, three hundred and fifty miles. If the gradation in the decreasing thickness of the vein had continued, without change, the great Pittsburg vein would have been reduced to nothing long before reaching the Kentucky coal-fields.

*See Lesley's Manual of the coal, p. 84.

Coal No. 9. This is, in western Kentucky, a reliable bed, and its coal is generally of very good quality. It is so well characterized by the fossil remains of its shales, that it is easily identified. Its thickness varies from three to five feet, and it is covered with a thick bed of black, hard, laminated and slaby shales, which contains a quantity of vegetable, but especially of animal, remains. The plants preserved in the shales are mostly stems of ferns, and pieces of the bark of *Sigillaria*. The shells, much more numerous, at least as individuals, have two species, which may be taken, among others, as characteristic, viz: *Avicula rectalateraria* and *Productus muricatus*. Teeth, scales, and fins of fishes, (*Icythyodorulites*) are also found in the shales of this coal, with the shells, but those remains are in great abundance only where the shells have disappeared; we have found them in all the places where we had an opportunity for the examination of the vein, ordinarily accompanied by a conical, regularly-ribbed print, about half an inch deep, and nearly as broad at its base. This fossil has been referred to a peculiar scale, which covers the head of a kind of fish, *Cephalapsis*, of which the caudal square and shining scales, are also found on the same shells with remains of small *Pterichthys*, another species of fishes of the Coal Measures.* Sometimes, also, these remains were accompanied with well marked small *Calamites*, which, from their length and their slenderness, appear to have lived in deep water.

The remains of fishes which abound in the shales of coal No. 9 are also found, apparently of the same species in the shales of coal No. 11. In this way, if the identification of both these veins should repose on palæontology alone, it would be sometimes impossible to make a distinction between them, except by means of the shells, which, however, are not found everywhere. The shells themselves are numerous, and of species so very like that it requires a good deal of scientific perspicacity to distinguish them. But the identification, or rather the distinction of the beds is easily made out from this difference, that No. 11 coal is ordinarily separated into two by a clay parting, and that its shales are covered by limestone, either as a more or less well developed continuous or interrupted limestone, or indicated by a ferruginous clay, containing the shells of this limestone. Moreover, the shales of No.

*Lyell's Manual of Geology, p. 344, 345.

9 are generally of a coarser texture than those of No. 11; under the microscope they appear covered with small whitish spots, which are either very small shells or crushed grains of sand.

In regard to the distribution of the shells, it is necessary to recall here what we have said on the distribution of the plants. In the shales, of two beds formed near each other, all the species cannot be different, therefore, the change in them ought to be examined with the greatest care, before we decide that a palæontological distinction is impossible, because some species of shells or remains of fishes are identical in both beds.

Though the fire-clay of the bottom cannot give precise indications, we may mention that below coal No. 9 this clay is thick—from ten to twenty feet and more, and insensibly passes into a hard rock, resembling a variegated limestone. At Hartford it forms along the river true perpendicular cliffs. This particular hardness, thickness, and color of the fire-clay, attracted lately my attention to a bed of coal, exposed in a cut of the Pennsylvania Railroad, about three miles east of Greensburg. Supposing that it might perhaps indicate an identical horizontal level with our No. 9 coal, I had the black roof shales opened, and by examination found them to contain the same remains of fishes as those enumerated above. This bed of coal, only one foot thick, is separated, by limestone, shales, and sandstone, from another thick vein of coal, which is exposed still higher, and it is in the vicinity of this last coal, and just at the eastern end of the tunnel, that I collected, in great abundance, and in a perfect state of preservation, many species of shells which, after examination, Mr. E. T. Cox pronounced to be all of the same species as those of our 11th coal. Thus we have here the thick, hard, colored fire-clay, and the remains of fishes of coal No. 9, and with the coal above it the characteristic shells of No. 11, to show evidently the concordance of the geological level at both places, in the Pennsylvania and western Kentucky coal-fields. The veins of coal mentioned above, and exposed in the great cut before the first tunnel east of Greensburg, have evidently their place in the great limestone of the upper Coal Measures of Pennsylvania—the lowest about one hundred feet above the Pittsburg coal, the other somewhat higher, between two beds of limestone, of which the inferior is more than twenty feet thick. This is a new and remarkable coinci-

dence, since, in the Holloway's boring, near Henderson, Ky., our 11th coal is found also between two strata of limestone, the upper four feet thick, the inferior eight feet. Thus the supposition that the Pittsburg vein is represented by the 8th coal, in the western Kentucky coal-fields, is confirmed, since the distance to No. 9 is the same as that marked in Lesley's Manual, between the Pittsburg vein and the 1st coal of the great limestone.*

Before entering the western coal-fields of Kentucky, we had good opportunity to study the shales of No. 9 coal, first at the Shawneetown Mining Company's mines, and then at the Saline Company's mines, Illinois. At this last place, especially where the coal is extensively worked, we saw the characteristic shells in the shales, especially *Avicula rectalateraria* and *Productus muricatus*, with some remains of fishes and large nodules of iron, sometimes perfectly round and of immense size, containing at some places a great number of shells, and even fine pieces of petrified wood. They are especially formed of sulphuret of iron, and so hard that they can only be broken after they have been roasted in the heaps of burning shales.

Curlew mines, Union county, Kentucky, No. 9, is here the main coal, four feet thick, covered with thick black shales, in which are imbedded large nodules of sulphuret of iron. With the remains of fishes. *Avicula rectalateraria*, is the only shell that we found in the shales, and even it is scarce here. Generally speaking, this shell is unequally distributed—sometimes extraordinary abundant, and sometimes entirely wanting over extensive surfaces. At Curlew mines, the shales contain also large pieces of *Sigillaria*.

Mulford's mines, Union county. The main coal here is still No. 9; it is four to five feet thick, covered with the same thick black shales as at Curlew, but with a much greater abundance of fossil shells. *Avicula rectalateraria*, and especially *Productus muricatus* are accumulated in the shales in such quantities that they cover them sometimes entirely. The large nodules of iron, also, of which some had been burnt and broken, were seen to contain quantities of different species of shells, especially large bivalves and fine pieces of wood.

Jackfield's coal, at Capt. Davis', Hopkins county. Though the coal No. 9 is not worked here, it has been opened and its shales exposed

*See Lesley's Manual of the coal, p. 84.

well enough to permit its identification. The coal is four to five feet thick, and the black shales above it contain the teeth and remains of fishes, characterizing both No. 9 and No. 11 coals. The coal has no clay parting, and no limestone above it. About half a mile above Pidgeon run coal bed, in a rivulet near Capt. Davis' residence, there is an out-crop of coal, which appears to belong to the same No, 9, opened by Thom. Davis.

Peaks of Otter coal, on the head waters of Steward's creek, Hopkins county, is four to five feet thick, and is covered with shales of exactly the same appearance, and with the same fossil remains as the former. It has no clay parting, and no trace of limestone above the shales.

Coal No. 9 is also open and worked four to five feet thick, at the Peaks of Otter, near Alfred Town's house, with exactly the same shales as above.

McNairy's coal, Pond river, Muhlenburg county. No. 9 coal crops out here, in the bed of a rivulet, where we could examine a few shales only. They contained the remains of fishes. The coal is not opened, and appears to be five feet thick.

Near the road from Greenville to Paradise, about two miles east of Greenville, we examined two beds of the coal No. 9. The first, Capt. Wing's bank, is two feet thick; the other, Isaac Luce's bank, one mile distant on the other side of the road, five feet in thickness. Both beds are without clay partings and limestene, and are covered with black slaby shales, marked with the same numerous remains of fishes belonging to this coal.

Airdrie, Muhlenburg county, Kentucky. No. 9 coal is not worked now at this place, but it has been, in a shaft sunk from the top of the hill. The shales of this bed are still heaped up near the opening, and were easily identified. Though there can be no doubt about the position of this bed here, since it is marked by the section of the shaft, it was interesting to ascertain the identity of the fossils. The coarse grained shales of this bed, exactly of the same texture as those of all the beds before mentioned, contain also exactly the same remains.

Hartford, Ohio county, Kentucky. The same No. 9 coal is seen at this place, on the banks of Rough creek. The coal is only two feet thick. It has the same shales, the same remains of fishes, a few shells,

Avicula rectalateraria only. We have mentioned before, that at this place the thick fire-clay below the coal insensibly passes into a hard rock, cut in bluffs, along the river.

Lewisport, Hancock county, Kentucky. The main coal opened near this place, one and a half miles from the Ohio river, still belongs to No. 9. The vein is not worked now, but the old shales, though very much decayed, afford materials enough for identification. Among the shales there are some boulders of limestone, or rather nodules of iron, which contain an abundance of the same shells that we found at Mulford's, especially *Productus muricatus.* One mile further west of this place, the same coal is worked now in a small way, for the demand of the town. It has here the same slabby shales, with the same fossils. The main thickness of the coal at both places is four feet to four feet four inches.

Henderson shaft, Ky. The 9th coal is reached here about one hundred and ninety feet from the top of the shaft, as marked in the section, p.p. 36 to 39 of the first report. The shales of this bed are easily distinguishable in the rubbish, having in them the fossil remains of fishes, and the *Avicula rectalateraria.* The palæontological identification is here of small interest, because the shales of the shaft are all mixed together in a heap, and also because the section itself gives the best indication about the place of this coal. This section agrees nearly foot by foot with No. 1, vertical diagram of the report of the Saline Company, Ind. The distance from the coal, two feet four inches, little Newburg coal, which is No. 11, is one hundred and eight feet, showing the total absence of the middle coal. At Saline Company it is one hundred and two feet, and at Shawneetown Company, Ind., one hundred and ten feet.

Coal No. 10. This vein appears to be the most unreliable and inconstant of all. It looks like a wandering bed, sometimes high up, sometimes descending, most of the time entirely absent or joined to No. 11. I would have omitted its description if we had not seen it at Shawneetown Company mine, where it has been scarcely opened. The coal, two to three feet thick, looks brittle and oxidated, an appearance possibly caused by atmospheric influence, and disintegration of the outcropping part. The roof shales are black, hard, compact, not slabby, but irregularly breaking, and without any traces of shells. The bot-

tom is a micaceous coarse fire-clay, full of *Stigmaria*, resembling sandstone shales. This is all that we can possibly say of this bed, which entirely disappears, at least as an isolated bed, in all the part of the coal-fields that we have explored. The shaft of the Henderson Company shows there its total absence; at the Holloway boring its place only is marked by a three feet two inches bed of black shales, with some little coal; at the Airdrie shaft there is no trace of it; at Curlew and Mulford's, coals No. 9 and No. 11 are open on the same hills, and the place of No. 10 is indicated only by a coal dirt. If we had found it at any other place the remarkable conformation of its fire-clay would have afforded an easy identification of it. The only way of accounting for its disappearance is by supposing that it is generally part of coal No. 11, and that at Shawneetown Company mine, where it is separated from it by forty-three feet of shales, it has somewhat gone out of its way. Perhaps this is the cause of the irregular and sometimes large thickness of No. 11, and of its one and sometimes two clay partings, also very variable in their thickness.

There is about the position of this bed a difference between the topographical assertions and our own. But this difference is probably caused by mistaking, in some places, No. 11 for No. 10. With such beds, unreliable in their directions, the topography, by itself, and without the aid of the palæontology, must necessarily lead to error.

Coal No. 11. This is a peculiar, generally very fine and well developed bed of coal, though varying from two to nine feet in thickness. We have previously observed, that as regards the remains of fishes, especially, there is a remarkable identity in the palæontological characters of this and No. 9 coal. The shells appear to be generally of different species, and especially distributed in a different proportion. From the notes of Mr. Cox, who may perhaps change the nomenclature of the shells after a more careful examinatiou, No. 11 coal is especially characterized by an abundance of *Pleurotomaria* of various species; *Productus Rogeri?* (N. and P.;) *Nucula Hameri?* and by a large *Avicula*, resembling *Avicula rectalateraria*, but larger and with a difference in the ribs of the side wings. The fossil plants are not so generally distributed in those shales as in No. 9, especially the *Sigillaria* seems to be wanting. The shales also are of finer texture, more bituminous,

and not so easily separated into slabs. The remains of shells are generally much more numerous, and the number of species much greater. This bed can generally be recognized by its parting. But it should be observed that when the vein thickens much the clay partings are double, and when it thins to two or three feet, there is, ordinarily, none; but this last case is very rare.

Curlew mine, Union county, Kentucky. At this place, about one hundred feet above the main coal, we had the first good opportunity of studying the coal No. 11, and of collecting the fossil shells of its shales. All the characters above described are found there. The coal at Curlew, as of Shawneeton Company, Illinois, is mostly bird-eye. In the anthracite coal-fields of Pennsylvania, there is also a peculiar bed, in which this kind of coal is generally seen. It would be very interesting to ascertain if both these beds are on the same geological level. This I was unable to do, since I saw only specimens of the coal in cabinets, but never the place where they had been taken.

At the Curlew mine, above the shales of No. 11, there is a bed of fossiliferous limestone.

Thompson's mine, Union county, Kentucky. Coal No. 11, is open at this place. It is six feet thick, has a clay parting, and the shales contain the remains of fishes, and some of the above mentioned shells. There is above it a bed of limestone, passing into brown ferruginous, hardened clay, full of fossil shells of the same species as in the limestone.

Llewellyn mines, Union county, Kentucky. Same coal at this place, about six feet thick, with clay parting, and limestone above the shales. The shales, though thin, have the same fossil remains as the former.

Providence, Hopkins county, Kentucky. At this place the coal No. 11, crops out around the hill, on which the town is built. Its characteristics are exactly the same as at Thompson and Llewellyn, viz: coal five to six feet thick, with clay parting, covered with black slabby shales, with remains of fishes, and some shells, and above them the limestone, passing into rotten ferruginous brown stone or shale, full of fossil shells, especially of a *Productus Rogersi*, marked with short spines. About one mile west of the town, among the hills, there has been opened a bed of coal, four to six feet thick, which has the same shales, but wants the limestone above them. Nevertheless, the place

of this limestone being indicated by a thin bed of yellow ferruginous clay, with fossil shells, we referred this bed to the same coal 11, with some doubt.

Pigeon's Run, Hopkins county. This coal is No. 11, eight to nine feet thick. It has a clay parting, and is covered with four to five feet of black shales, always containing the same fossil remains as those mentioned above. The limestone above it is irregular, mostly in boulders or large slabs, as at Thompson's mines, and at the Shawneetown Company's mines.

In Hopkins county, Kentuky, No. 11 coal is opened at the Sisk bank, and seen at some other places around in Town's property, with the same shales and limestone.

Arnold's mine, four aud a half miles south of Madisonville, Hopkins county. No. 11 coal is here eight feet thick, has two clay partings, and a thick bed of black slabby shales, with an abundance of fossil remains, fishes, and shells, which give character to this coal. The slabs are covered with limestone.

McNairy's coal, Pond river, Muhlenburg county. No. 11 coal is opened here at two places, seven feet thick. The clay parting, the shales, with their characteristic fossils, and the limestone above them, are found at each place. Here, also, coal No. 12 is present, and comes so near No. 11, that it is separated from it only by its floor of two feet six inches of fire clay, and by the limestone (one foot thick,) of No. 11 coal.

Miller's coal, on Isaac's creek, Muhlenburg county, belongs to No. 11. It is six feet thick, has its usual black shales, with the before mentioned fossil remains, its superimposed limestone, and a clay parting. The brown ferruginous and fossiliferous clay or shale is also present here, covering the limestone. This ferruginous shale is sometimes above, sometimes below the limestone, and sometimes takes its place.

Airdrie, Muhlenburg county. Coal No. 11 is here the main coal, six feet thick, with clay parting. The black shales contain an abundance of beautifully preserved shells, and also scales, fins, and teeth of fishes. They are covered with a limestone bed three feet thick.

Bonharbour, Daviess county, Kentucky. There is no place where No. 11 coal is so easily identified by palæontological observations. The coal about five feet thick, has an occasional clay parting, or is separa-

ted by a thin layer of sulphuret of iron and charcoal. It is topped by the black slaby shales, with great abundance of shells, and some remains of fishes; and above it, has a soft calcareous rock, also full of beautifully preserved shells, all species characteristic of this coal. Near Curdsville, opposite this place, on Green river, in Henderson county, No. 11 coal has been worked, and is here called Cook's upper coal. The coal, four feet thick, has a clay parting; its black shales are full of shells, as at Bonharbour, and it is covered by two beds of limestone, separated by a bed of coal-dirt and fire clay, six inches thick. The inferior bed of limestone is full of shells, but the superior one is black and without remains of fossils.

Coal No. 12. The general features of this coal recall the same observations as for No. 10. Its formation has followed too near that of No. 11. It is an unreliable bed, as well for its thickness as for its position. It sometimes comes so near No. 11, that it looks like a part of it, and sometimes it is found twenty or thirty feet above it. Its palæontological characters are well marked by an abundance of remains of fossil fishes, especially large scales, and large (mostly double) teeth. In Nos. 9 and 11, the remains of fishes belong only to very small species; in this they are much larger. The double teeth, found in abundance at Airdrie, are of a peculiar structure, viz: divided into two hooked points, about half an inch long, diverging from the base.

Exclusive of its fossil remains, coal No. 12 is easily identified by the composition of its coal, which is mostly a dirty, rashy, coaly matter, a compound of flattened *Stigmaria*, *Calamites*, and some scarce *Sigillaria*, well preserved in their outlines. Coal and shales are covered by a black band, or bed of calcareous iron stone, passing to a black limestone, which sometimes takes its place. This limestone is not fossiliferous, as far as has yet been observed.

Airdrie, Muhlenburg county, is the first, and truly the only place, where we had a good opportunity of studying No. 12 coal. It is opened here for the black band from which the material is supplied to C. H. Alexander's furnace. The bed of coal about four feet, has two to three feet of coal-rash, apparently entirely formed of *Calamites*, *Stigmaria*, and *Sigillaria*. I could not find a *Lepidodendron* among those vegetable remains. Below the coal-ash there is one to one and an half feet good coal. The shales, one foot thick, are parted by the

black band, which sometimes disappears, sometimes occupies the whole thickness of the shales. The black band itself does not contain any fossil remains; but at all the places where it is not formed, the shales contain, in abundance, the remains of fishes mentioned above.

Besides at Airdrie, we observed this 12th coal over the limestone in the peaks of Otter, on Town's property, Hopkins county, Kentucky, where it is a rashy coal, three to four feet thick, and has a black band parting shale, with the remains of fishes. At McNairy's, Muhlenburg county, Kentucky, where it comes within two feet and a half of No. 11, and is a rashy coal, with black limestone between it and No. 11; opposite New Curdsville, in Henderson county, where it has only six inches coal dirt, comes to within three feet of No. 11, and has limestone both above and below it, and probably also at the top of Gamblin hill, Hopkins county, where we saw its out-crop only, in a hole full of water, which prevented closer examination. This bed is no where open in such a manner that it could be studied satisfactorily. It is indicated at other places, but always as a rash and unreliable coal.

This terminates the series of local information that we were able to collect in one month of palæontological survey in the western coal-fields of Kentucky. Perhaps the results may not be accepted as entirely satisfactory; but, considering the short time, and the extent of country surveyed, we think that it was hardly possible to obtain a larger amount of useful information. Not only the true vertical extent or the thickness of the Coal Measures of Kentucky is at once fixed, bnt the geological level of many important stations is ascertained, and these may serve as points of comparison for future investigation. Moreover, the first basis for the determination of the coal-fields, by palæontological remains, is laid down in this report, and every observer may test its value, and find out every fact that can modify or consolidate it. For, though the most valuable beds of coal of Kentucky have had their essential characters pointed out in such a manner that every geologist will easily know them again every where, yet there is a great thickness of the Coal Measures that is still nearly unexplored. This part contains, wrthout doubt, the less important and less valuable veins; nevertheless, the study of coals Nos. 2, 3, 5, and 8, may be of great interest in a scientific point of view. For this the collection of all the fossil remains, plants, shells, fishes, with refer-

ence to the place where they have found, and if possible to the supposed geological level of it, will prove the most valuable contribution.

I thought at first to examine, in detail, the question of the identity of all the coal-fields of the Mississippi valley, including the great Apalachian and the anthracite fields of Pennsylvania. But a scientific discussion would take too much space in a local report like this, and I can only offer out some general remarks, which will at least explain this belief: that the western Kentucky, Illinois, and Indiana coal-fields were formed in continuity with the great Apalachian basin, and the anthracite fields of Pennsylvania. The comparison will be better understood by looking at the description of the lower coals, as it is given on pp. 94 and 95 of Lesley's excellent Manual of coal. His coal A, a thin bed, the first above the conglomerates, is sometimes present in western Ohio, as at Nelsonville, where it is about two feet thick, and in Virginia, as on the great Kanawha, near Charlestown, where it is eigteen inches thick; but, nevertheless, it is scarcely seen or penetrated in the borings for salt. As the system of the lower coals is less developed at the west, a circumstance easily explained by our general remarks, this bed of coal, when formed in the eastern coal-fields of Kentucky, is only a thin layer. In a shaft of the Old Distillery mines, at Caseyville, this bed is said to have been reached, and found to be one to two feet thick. But truly we could not find any reliable account of this.

Coal B, of Lesley's Manual, viz: our coal No. 1, B, is in the western Kentucky coal-fields, as well as in Ohio, Virginia, and Pennsylvania, a most reliable vein, and undoubtedly the *best* of the whole series, considering the extent of the surface where it becomes exposed. It thickens to the east, and in the anthracite fields it forms the Mammoth vein, and many others of the largest veins which have been worked. As a proof that its characters are everywhere the same, I quote a few lines of my palæontological report prepared and delivered in 1852, for the Geological State Survey of Pennsyivania:

"As soon as we come to the lower strata, the presence of large vegetables becomes apparent, first in the great quantity of *Stigmaria* abounding in the shales of the Diamond and Primrose veins, then in the *Lepidodendron*, and some large ferns which distinguish the Mammoth vein. This vein especially merits to be mentioned for its peculiar flora. The roof slates, of gray color, ordinarily charged with nodules

of iron, have preserved the impressions of fossil plants in a very good state. The ferns, when present, belong to the largest species. With the *Lepidodendron* and their fruits, found in great abundance at Wilkesbarre, Carbondale, Minersville, Tamaqua, and Summit Lehigh, the ferns mostly seen in these low veins are *Alethopteris Serlii*, with its near relative *Alethopteris* (*Pecopteris*) *lonchitica*, and also with *Neuropteris hirsuta* and *Neuropteris Clarksoni*, Lsq'x. The fruits and needles of *Lepidodendron*, viz: *Lepidostrobus* and *Lepidophillum*, are also very abundant in the Mammoth vein of the anthracite, and since we did not find any specimens of these fruits any where else, viz: in any other bed above, their presence may be relied upon as a true character of the lowest beds of the coal basin in general, (p. 8 to 9, MSS.)

"We have already alluded to the identity of the great Apalachian coal with the anthracite formation, asserting that this identity is especially striking by comparison of the flora of the different strata.

"The lowest bed of the basin (our coal No. 1, B,) rests on the conglomerates, and crops out at Summit Portage, where we collected some *Lepidodendron* and *Lepidophillum;* at Johnstown, where the black slates of the roof are charged with *Lepidostrobus*, especially with *Lepidostrobus brevifolius*, Lsq'x., and also with *Lepidodendron*, at Cuyahoga Falls, Ohio, where the shales abound with the same plants, and also with *Pecopteris lonchitica*, and some *Sigillaria*. There is also there plenty of fruits—*Cardiocarpon*, *Carpolithes*—as at the low vein of Trevorton, Penn. The last place where we had opportunity to examine this vein, so rich in fine fossil vegetables, is on the great Kanawha river, three miles above Charlestown, where we found the roof shales covered with *Alethopteris Serlii*, and with some fine *Lepidodendron*, and *Lepidostrobus* in abundance. From this we shall necessarily be permitted to draw this conclusion: that this vein of coal, preserving so well it characteristic fossil plants, and at so great distances, was formed at the same time, and under the same circumstances, as well in the whole extent of the great Apalachian coal as in the anthracite coal-fields." (Pages 10, 11, MSS.)

This is nearly a repetition of what we have said about the lowest bed of coal, viz: No. 1, B, of the western coal-fields of Kentucky; and for this basin, also, we must necessarily draw the same conclusions as above.

The correspondence of No. 2 coal with cannel coal C, of Pennsylnia, of our No. 4 with the Pomeroy vein of Ohio, and with the Gates and Salem veins of the anthracite, at Pottsville, as also the relation of No. 6 coal with the Steiger's bed of Athens, Ohio, have been already and sufficiently pointed out.

The barren measures, from the Pomeroy coal up to the great Pittsburg vein, are perhaps not as well developed in the western coal-fields of Kentucky as in the great Apalachian basin; but, following our general remarks, all the strata have necessarily thinned somewhat westwards. Nevertheless, the space occupied in Kentucky by these barren measures, is three hundred feet thick, which is as much as in some places of Pennsylvania and Ohio. It is true that the measures are not entirely barren in western Kentucky, since there is a coal, No. 5, four feet thick, at ninety-five feet above No. 4. But the same vein is well developed in Ohio, near Athens, at one hundred feet above the Pomeroy coal, and in Pennsylvania, where the barren measure take their greatest developement; the same coal, one foot thick, is generally found at about fifty feet above the Mahoning sandstone, which rest upon the Pomeroy coal, and is seventy feet thick. This great sandstone, which is sometimes a bed of conglomerates, follow westward the same decreasing progression as the true conglomerates of the coal measures.

Nos. 6 and 7 coal, generally thin beds, have, in the western coal-fields, taken the place of the limestone of Pennsylvania, according to this principle, that where a quiet water is high, and the marine element predominating, a limestone may be formed, when at the same time, in more shallow marshes, the plants will grow, and their remains make a deposit of coal or shales; for it is evident that though the whole of the Coal Measures appears to have been horizontal, at least at some periods of formation, there has been, in different places, some depressions, forming lakes in the peat growing marshes, and that these lakes had to be filled by sand or by formation of shales, or of limestone, before they could again be covered with vegetation, and consequently with coal.

If the examination of the fossils of No. 8 coal, shows it to be the true coeval of the Pittsburg vein, we have, from it to the highest point of the Coal Measures, as far as they have been surveyed in the United States, another striking analogy in the position of the veins of coal, and their respective distance in both the coal-fields of western Kentucky and Pennsylvania. Admitting the coal marked three feet five inches, in the great limestone of Pennsylvania, as our No. 11, with which it is in perfect concordance by its fossils, and admitting that our

No. 12 is either united with it or not formed as in western Kentucky, we find in Pennsylvania, according to Lesley's *description of the upper Coal Measures,* a bed of coal, one foot thick above the great limestone, covered by two thick formations of sandstone, one fifteen feet, the other thirty-five feet, separated by shales, and a thin bed of limestone—the whole thickness of these strata being sixty-five to seventy feet. In Kentucky, between 12 coal, and the first coal above, there is ninety-five feet of sandstone and blue slate; and from this coal, which, for convenience sake, we will call No. 13, there is thirty-six feet of shales and limestone, to a five feet black slate, which contains some coal, and then thirty-seven feet of brown slate and limestone, to a bed of coal, (say No. 14,) which is thirteen inches thick. In Pennsylvania, we find, in the same space, fifty feet of sandstone and shales, to a coal eighteen inches thick, and then fifty-five feet of limestone and shales, to another coal one foot thick, covered by four feet of brown shales, and twenty feet of sandstone. And more, if we count the whole thickness of the strata from the highst vein of coal in Pennsylvania to the Pittsburg vein, we find it to be marked by Lesley at four hundred feet, and the distance from our 14 coal to No. 8, or Well coal, is nearly exactly the same, viz: three hundred and ninety-five feet.

Truly this extraordinary concordance of the Coal Measures, at many hundred miles distance, is a very remarkable geological fact; and may be accepted as a proof, not only of coevity, but of continuity of the now separated coal-fields.

It may be said that a coevity of formation would, perhaps, call in existence the same formations, on both separate basins, as well as on a continuous one. This is possible, but there is nothing to prove it. On the contrary, we find, on the true borders of the great Apalachian coal-fields, viz: on its eastern and northern limits, many peculiar accidents of formation, great irregularity of thickness in the strata, distortions, cavities, subdivision of the bed of coal, which show the action of the sea on its shores, where the sand is unequally distributed, and where some small basins are closed and separated from the main one; and also on the western borders of the Apalachian, as well as on the eastern limits of the western Kentucky coal-fields, the veins of coal, and even the intermediate strata, have a remarkable uniformity of thickness. From Massillon, Ohio, to the Ohio river, at Nelsonsville and

other places, coal No. 1, B, is from four to six feet thick, and along the eastern borders of the Illinois coal-field, as at Hawesville and Breckinridge, the same coal is four to five feet in thickness. As far as I have been able to extend my explorations till now, I have not seen any part of the coal-fields, east of the Mississippi, which give indications of having been separated from the general coal-fields at the time of their formation, except the anthracite basins of Pennsylvania; and I still think, that even these were connected by channels with the general basin, and that these channels have been often obstructed. That the high and quiet water of the sea has never covered them, is evident, from the total absence of limestone and shells in their strata, and also from the great thickness and the subdivision of the beds of coal; while in the general basin, the growth of the vegetation of the coal was sometimes stopped by the slow invasion of marine water, in the enclosed marshes of the anthracite fields, the growth of the vegetable materials was continuous for a longer period, and stopped only by the invasion of the sand brought upon them by a greater depression of the whole surface. In this case, we may find the fossil plants to represent the same species in the beds of coevel formation; but these species may be distributed in another manner, viz: appear identical in two or three veins close to each other, when in the general basin, they belong to a single vein. The case is observable near Pottsville, Wilkesbarre, and a few other places, and can be explained only by supposing that while the coal-field was submerged, some disturbance has strewn a bed of sand upon the already growing marshes of the borders, and that the vegetation beginning again, before a general change by depression or upheaval, the plants were of the same species as the former. I still persist in the affirmation of my report to the Pennsylvania geological survey, that the Salem and the Gates veins, as well as the Black and the Lewis veins around Pottsville, belong to the same bed of coal. But if this assertion should be proved a mistake, the identity of the fossils of those veins could not be explained but by the above supposition.

But, it is asked: if the upraising of the lower formations, which has caused the coal-fields to be separated by about two hundred miles of Devonian and Silurian strata, was posterior to the formation of the coal, what has become of the upraised Coal Measures, and where is

the proof that they have been destroyed by subsequent erosion? The proof is found in the quaternary formations, all along the Ohio and the Mississippi rivers. The loam deposited by these rivers is sometimes mixed with broken and rolled pieces of coal; there are even some deposits of alluvial rolled coal, or pebbles of coal, heaped in strata in such a way that they have been taken, by unexperienced observers, for true coal beds. I had opportunity to examine one at low water of the Ohio river, below Vevay, Ind., in an alluvial formation, just upon the Lower Silurian Measures, and I have heard of some others.

But here we must close this already too lengthened discussion, and let the reader draw his own conclusions from the facts enumerated above, and also apply the general rules to the different localities open for his examination. There are, no doubt, some phenomena of the formation of the coal that are not yet satisfactorily explained, and some local accidents which will baffle every effort toward a generalization. But the science of the coal is still new, especially in the United States, where the coal-fields have been till now regarded only as true mines of wealth, very good for working, but scarcely worth a careful scientific study.

Explanation of the Plates.

PLATE VI.

FIG. 1. *Sphenopteris tridactylites*, Brongt? Our species, found at Union Company mines, somewhat differs from the European species, by its longer *tertiary pinnules* and its broader punctulate rachis; it is probably a peculiar species; 1a shows a tertiary pinnule; twice the natural size.

FIG. 2. *Neuropteris flexuosa*, Sternb. Giger's vein, Greenup county, Ky.

FIG. 3. *Pecopteris lonchitica*, Brongt. Upper part of a frond. The secondary pinnæ like *a* are mostly found. Low coal. Union Company mines, &c.

FIG. 4. *Neuropteris hirsuta*, Lsqx., with stem. The leaflets are mostly found separate. Common in the whole extent of Coal Measures. Very variable in its outlines.

PLATE VII.

FIG. 1. *Lepidodendron politum*, spec. nova. General scars oval lanceolate pointed curved at both ends with broad inflated, scarcely ribbed margins. Impressions rhomboidal, obtuse above, narrowed at the base, marked with three obsolete points; appendages two, united to the margin; no medial line nor wrinkles on the smoth scars. Union Company mines, Ky.

FIG. 2. *Stigmaria ficoides*, Sternb., with flattened leaves as it is ordinarily found in the coal and the shales. Fig. 2a shows part of a round leaf as preserved in the sandstone.

FIG. 3. *Lepidostrobus*. Low coal, Bell's mines, Hawesville, &c.

FIG. 4. *Sigillaria obovata*, Lsq'x. MSS. in Pennsylvania report. Low coal.

FIG. 5. Cross section of a small *Lepidostrobus*.

FIG. 6. *Lepidophyllum crevifolium*, Lsq'x. MSS. Pennsylvania report, pl. 23, fig. 6.

FIG. 7. *Lepidophyllum lanceolatum*, Brgt. These three last species are generally found in the low coal.

FIG. 8. *Carpolithes plati-marginatus*, Lsq'x. MSS. in Pennsylvania report, pl. 23, fig. 12. Low coal. Union Company mines, &c.

FIG. 9. *Carpolithes bicuspidatus*, Sternb., common in the low coal of Kentucky.

FIG. 10. *Calamites tuberculosus*, Gutb. Rash coal, Kentucky.

PALÆONTOLOGICAL REPORT

OF

COAL MEASURE MOLLUSCA

MADE BY

EDWARD T. COX,

ASSISTANT GEOLOGIST.

REPORT.

TO DR DAVID DALE OWEN,

Geologist of the State of Kentucky.

SIR: In accordance with your instructions I accompanied Mr. Leo Lesquereux in an excursion for the purpose of examining the coal field in the western part of Kentucky, with the view to collect palæontological data, that might greatly aid in identifying the different veins of coal, one with another, throughout the counties embraced in its extent; especially by means of the organic remains found in the roof-shales and accompanying rocks.

The merited celebrity of Mr. Lesquereux as a fossil Botanist, and the important labor which he had bestowed upon the coal plants of Pennsylvania and Ohio, made his selection for a similar work in Kentucky, the very best it was possible to make.

In connection with Mr. Lesquereux, I was especially instructed to pay attention to the fossil mollusca, and collect every possible evidence for identity from that source. This mode of establishing the position of coal beds has only been practically pursued by Mr. Lesquereux in this country; and a beginning is now being made, for the first time, to connect with the flora the testimony of the shells—an addition much needed in western Kentucky, on account of the great scarcity of the former, and abundance of the latter.

Our investigations, for identity, commencing with coal No. 1, B, at the bottom of the section in the first chapter of your report, and terminating with coal No. 12, includes, in all the strata, a vertical thickness of about eight hundred feet. It must not be supposed that these members include the whole thickness of the western coal field; though they mark, probably, the limits of the profitably working coals, there are one or two thin seams below No. 1, B, which, with a thick sandstone, usually pebbly, with underlying shale, make together one hundred feet or more; whilst above No. 12, there are a number of thin veins with intervening shales, limestone, and sand-rock, in all upwards of five hundred feet, making the whole measures in the western

part of the state from (1,400) fourteen hundred to (1,500) fifteen hundred feet.

The thin veins above No. 12, are not wanting in distinctive organic remains, and collections had already been made from some of these higher beds, amongst which are seveal new species. They have been omitted for the present, as being of the least importance, and because they require additional study.

In Mr. Lesquereux's report will be found an extremely interesting account of the formation of fossil fuel, and the equivalency of the various beds of coal throughout the field of our examination. It remains only necessary for me, on this occasion, to refer to each vein its peculiar fossil shells, so far as they have been ascertained.

It may be asked, how came marine shells to be imbedded in the roof-shales, if the coal has been formed in fresh water? They followed the influx of the sea after subsidence of the land, and are such as usually live in shallow or brackish water, belonging to the phytiferous (vegetable feeders,) and carniverous orders. The salt water gradually killed out the coal flora—the last remains of which mixed with algæ, became entangled in the sediment of the ocean, and served to supply bitumen, with which the dark shales that usually form the roof of the coal are so frequently charged.

Our observations go to show that wherever we found fossil remains of the molusca abundant in the roof-shale, coal. plants are rarely found, whilst remains of marine plants are usually abundant.

COAL NO. 1, B.

This is the lowest workable coal in the western basin, varying in thickness from three to six feet, and characterized by a solitary molusca* *Lingula umbonata nob.*, plate X, fig. 4. It is opened and worked by the Union Coal and Iron Company, one and a half miles below Carrsville, in Livingston county, where it is an outlier, and the most southern workable coal in the state. This vein has been opened and worked by several companies along Tradewater river, in Crittenden county.† It is most extensively worked on the property of Col. John Bell, where it is from three and a half to six feet thick, and known as the "Bell coal." Another opening was made into this vein on the same

*For the flora see Mr. Leo Lesquereux's report.
†See report of Dr. D. D. Owen, State Geologist.

property, about three quarters of a mile farther from Tradewater, by Mr. Cook, whose name it bears.

In Union county it is mined by the Messrs. Casey's; out-crops near the old distillery back of Caseyville, also on the property of the Kentucky Coal Company, and various other localities in the same county.

On the eastern boundary of the basin it proves to be the main Hawesville and Breckinridge coal vein, at each of which localities we found the identical *Lingula umbonata* In the shales of the roof at Hawesville, where we had an excellent opportunity to examine, they were found in the greatest abundance.

The remaining figures on plate X belong to the *Cephalopoda* division of the mollusca, and were collected on a previous occasion by the survey, at Nolin Iron Works, Edmonson county. They are new, and occupy a low position in the Coal Measures, i. e., about one hundred feet above the conglomerate.

Very little has yet been done towards making openings into the other coals below No. 9, and what old workings have been undertaken are now mostly filled up, so that but little opportunity has been afforded for making collections from these beds. The only animal remains as yet found in them is from No. 7, or "*Black-band vein*," a thin seam of coal over-layed by a black bituminous, ferruginous carbonate of lime in thin bands, and these are fins, scales, and teeth of fish, that have not yet been determined. This vein, which is only noticed on account of its ferruginous calcareous black-band roof, from one and a half to two and a half feet in thickness, is best developed on the property of Mr. Alfred Towns, in Hopkins county, and usually contains from twenty to twenty-five per cent. of metallic iron. Its is also seen on the property of the Saline Mining Company, Gallatin county, Illinois, where it contains the same description of fish remains. Its position is about one hundred and thirty feet below No. 9.

COAL NO. 9.

This is the main working coal in the western part of the state, and is usually characterised by an abundance of fossil mollusca; amongst the most numerous are those figured on plate IX: *Avicula recta-lateraria*, *A. acosta*, *Solemamya soleniformis*, *Nautilus decoratus*, and *Productus muricatus*. Besides these there are *Nucula Hamerii*, *Nucula*, species undetermined, *Pecten*, species undetermined, *Pleurotomaria*

Grayvillensis, *Loxonema*, species undetermined, *Orthoceratite*, species undetermined, *Chonetes mesoloba*, (variety small, and prominently lobed,) *Productus equicostatus*, and *Bellerophon carbonarious*. This Bellerophon, which we propose to call *B. carbonarious*, has generally been refered to *B. Urei*, *Flem.*, by western Palæontologists—a conclusion with which we cannot agree; not from a desire to create a new species, but with a view to a proper understanding of the true geological position of the shells of the Coal Measures. The *B. Urei*, according to L. De Koninck, has a vertical range from the silurian to the carboniferous beds, whereas the *B. carbonarious* has not been found to range lower than the middle of the coal basin, and is only fully represented in the upper part. It certainly approaches very close to L. De Koninck's description of the *B. Urei*, (*Description Animaux Fossiles*, page 356, pl. xxx, fig. 4,) and may possibly be a variety, but cannot be considered identical. That there are several varieties or species referred to this shell, is evident from the description of the following authors here cited: *Capt. Portlock, Geology of Londonderry, page* 400; *Mr. Phillips' Geology of Yorkshire, page* 231; *M'Coy's Description of British Palæozoic fossils in the Geological Museum of Cambridge, page* 555; all of which differ materially. It is referred to *B. Urei* by *Norwood* and *Pratten*; *Notice of fossils from the carboniferous series of the western states*; *Journal Acad. Nat. Sci., June,* 1855; *page* 75, *plate IX., fig.* 6. The original of this figure is in my cabinet, and was loaned to them for representation, being at that time the only perfect specimen known. I an sorry to say, from some over-sight, for it was in the hands of a most excellent artist and esteemed friend, this figure gives a very incorrect idea of the shell; it exhibits but two-thirds of the true number of the spiral striæ—having only fifteen, whereas, there should have been twenty; (from the examination of a large number, they are found to range from 19 to 25;) the mouth, as well as the general contour, is essentially wrong. None of the various authors who have described the *B. Urei* mention the lateral expansion of the mouth into ears, a feature very decided in our shell. It also differs in having fewer spiral striæ, and by the more rapid increase of the last whorl. From the examination of several hundred good specimens, the average number of spiral striæ appears to be twenty-one, always, even in the youngest individual, terminating on the inferior

half of the last whorl, and have not been found to exceed twenty-five; whereas L. De Koninck reports on the *B. Urei*, from thirty-six to thirty-eight. *Dimensions*—Diameter $.\frac{78}{100}$ of an inch; proportional increase of the last whorl $.\frac{41}{100}$ to $.\frac{89}{100}$ of an inch; including the wings of the mouth; transverse diameter of the mouth $.\frac{44}{100}$ of an inch.

Remains of fishes, that have not yet been determined, are also found in the shales of this coal.

COAL NO. 11.

This is the next coal in the series, in which we found the remains of mollusca. For the most characteristic, see plate VIII., figs. 1 to 11, and plate IX, fig. 1. They are as follows: *Pecten Providencesis, Loxonema regularis, Chimnitzia parva, Pleurotomaria Bonharborensis, P. depressa, Arca carbonaria, Gervillia longispina, Plicatula striato-costata, Myalina pernaformis, Cardinia* (?) *fragilis, Macrocheilus, gracilis, Orthis resupinoides, Pecten*, species undetermined, *Avicula rectalateraria*, (not so abundant as in No. 9,) *Loxonema Hallii, Loxonema*, species nndetermined, *Macrocheilus inhabilis, Macrocheilus*, species undetermined, *Productus muricatus, rare, P. Rogersii, P. equicostatus, Athyris subtilita*, large and abundant, *Cardium*, species undetermined, *Spirifer Meusebachanus, Solenimya*, species undetermined, *Nucula*, species undetermined, *Orthis*, species undetermined, *Orthoceratite*, species undetermined, *Griffithides*, species undetermined.

This coal is usually separated into two members, by a clay parting from one to four inches in thickness, and is overlayed by a limestone. The upper part of this bed of coal is sometimes cannel, and the lower bituminous. It is best developed in Hopkins county—where it attains a thickness of nine feet—on the line of the Henderson and Nashville Railroad.

On the mining property of Edward and William Hawes, at Hawesville, Hancock county, No. 11 is found near the top of the hill, a few rods west of their entry into the main Hawesville coal, No. 1, B; well characterised by its peculiar fossils, and proves a remarkable thinning out of the measures near the eastern boundary of the basin. The vertical space between the two is here only two hundred and ten (210) feet, but may be somewhat increased, by the existence of an at present unknown fault.

COAL NO. 11.

This is the highest coal that we had an opportunity to examine in the series. It is characterised by the remains of fishes, not yet determined, and a small *orbicula*, of which we found no specimen sufficiently perfect for description.

As a full history of the coals, from the bottom to the top of the series, may be found in your report, and that of Mr. Lesquereux, it has been deemed unnecessary to repeat it here. There will also be seen, by a reference to the above reports, a demonstration of the fact, that the most persistent veins throughout the basin are Nos. 1 B., 9, and 11—they having been found at every locality where there is sufficient thickness of the measures to contain them.

For a better understanding of the fossil shells found associated with these coals, I herewith submit the annexed descriptions, and accompanying plates, Nos. VIII, IX. and X. For the beautiful and accurate representation of the fossil shells on these plates, we are indebted to Mr. John Chappellsmith.

The importance of the facts established by the survey of the coal-fields of Kentucky, cannot be over estimated. It has developed the various seams, and given characters by which the most important may at all times be known, and having established the identity of one, in any part of the basin, the relative position of the others may easily be known, by reference to the section in the first chapter of your report in this volume.

Next to agriculture, coal is the most important element of a country's prosperity and wealth. Its importance is just beginning to be felt in the west, and will increase with the constantly diminishing forest. As a fuel, it is the most convenient and economical, and no country can successfully compete in manufacturing without a cheap supply. It is the rich and well wrought coal-fields of England that enables her to maintain a supremacy in manufacturing, over the world; deprived of the coal, her importance as a nation would soon be lost.

In the British Islands not less than fifteen million tons of coal are annually raised, affording employment, in the mining operations, to more than one hundred and fifty thousand people. More than one third of this amount is derived from the Newcastle basin, embracing a superficial area of seven hundred and fifty square miles; whereas, in western Kentucky the coal-field contains more than three thousand

square miles, with an average thickness of all the coal seams about equal to those of the Newcastle district.

The superiority of coal as a fuel will be better understood when we consider, that one square mile of forest, containing twenty thousand trees, averaging two cubic yards of solid wood, would be equal to one acre of coal six feet thick. One hundred pounds of coal, occupying about one and a half square feet, will evaporate 1,200 pounds of water, equal to 150 gallons; while 100 pounds of well dried wood, occupying more than double this space, will evaporate only 700 pounds of water, equal to about 88 gallons; and six gallons of water evaporated in an hour is equal to a horse power.

E. T. COX,
Assistant Geologist.

A description of some of the most characteristic shells, of the principal coal seams in the western basin of Kentucky, by E. T. Cox, *Assistant Geologist.*

PECTEN PROVIDENCESIS. *Cox.*

(Plate VIII. fig. 1, left valve natural size.)

Semi-circular; as broad as high; nearly equilateral; left valve slightly convex; about thirty-three broad prominent ribs, of unequal width, and irregularly fluted; radiate from the beak to the circumference; crossed below the disk by two well defined bands, marking stages of growth. Anterior ear of the valve under description is wanting, but that of the right valve beneath, is in part exposed, finely ribbed, and crossed by concentric bands; inferior ear finely ribbed, crossed by fimbriating folds, curved outward from the beak. Rostral angle 95°; height $3.\frac{22}{100}$ inches; width $3.\frac{22}{100}$ inches. Its size and broad fluted ribs renders it easily distinguished from other species.

Position and locality. Found by the topographical assistant, Sidney S. Lyon, in the limestone which overlays the main coal, No. 11, at the town of Providence, Hopkins county, Kentucky. Fragments are somewhat numerous, but it is difficult to obtain them in as perfect a state of preservation as the one figured.

LOXONEMA REGULARIS. *Cox.*

(P. VIII, fig. 2, natural size.)

Elongated; acutely conical; volutions ten; regularly enlarging; convex; covered with fine transverse striæ; convex in the direction of the spire; sigmoidal on the last whorl; suture small, slightly impressed; body whorl about one half the whole length; colamella lip elongated, slightly reflected; outer lip thin; mouth about twice as long as broad; spiral angle 35°; length $2.\frac{10}{100}$ inches; width $.\frac{81}{100}$ inch.

It most nearly resembles *L. Halli, Norwood and Patten, Jour. Acad. Nat. Sci. June,* 1855, but differs in being larger, less acute, and more convex on the volutions. It was found by Sidney S. Lyon, Topographical Assistant, and is converted into pyrites of a bright yellow color and metallic lustre, and is in a fine state of preservation.

Position and locality. Rare, in a dark bituminous soft stratum of pyritiferous carbonate of lime; about one foot above the black shale forming the roof of the Bonharbour coal, No. 11, Daviess county, Kentucky.

CHIMNITZIA PARVA. *Cox.*
(Pl. VIII, fig. 3, enlarged; 3*a* natural size.)

Small; acute; volutions about six; very ventricose; marked with strong transverse ribs, slightly curved in the direction of the spire, and separated by a deep furrow as wide as the ribs; body whorl occupies about one third the entire length of the shell; columella lip slightly prolonged; mouth subcircular; length $.\frac{15}{100}$ inch; width $.\frac{9}{100}$ inch.

Position and locality. Occurs in the dark bituminous, pyritiferous, calcareous stratum over the shale roof of Bonharbour coal, No. 11, Daviess county, Kentucky.

PLEUROTOMARIA BONHARBORENSIS. *Cox.*
(Pl. VIII, fig. 4, enlarged; 4*a* natural size.)

Small; conical; a little longer than wide; volutions six; acutely convex; marked with a well defined concave band; distinct on all the whorls, and crossed with fine striæ; convex in the direction of the spire; ten to twelve spiral lines on the under part of the last whorl, diminishing to two or three on the preceding whorls; crossed by fine transverse striæ, rather strongly curved with the convexity in the direction of the mouth, giving a beautiful reticulation on the under part of the last whorl, and ornamenting the preceding whorls, on the upper part, with two to three spiral rows of small tubercles; spiral angle about 75°; length $.\frac{27}{100}$ inch; width $.\frac{21}{100}$ inch.

It differs from the *P. Grayvillensis, Norwood and Pratten, Jour. Acad. Nat. Sci., June,* 1855, *pl. ix., fig.* 7, by its ornaments, and in being more acute.

Position and locality. Abundant, in the roof shales of the Bonharbour coal No. 11, Daviess county, Kentucky.

ARCA CARBONARIA. *Cox.*
(Pl. VII, fig. 5, natural size.)

Transversly elongated; beaks not elevated; anterior extremity short; obtusely rounded; tumid at the umbo, from which a slight ob-

lique mesial sinus extends to the base, where it becomes profound; base emarginated; hinge area straight, almost forming a right angle with the posterior margin which is nearly straight; slightly sinuate above; obtusely rounded below; upper posterior part obliquely truncated; surface covered with concentric lines marking stages of growth, and fine radiating ribs, numbering on the disk about seven in one and a half lines; width $1.\frac{46}{100}$ inches, height $.\frac{69}{100}$ inch.

Position and locality. Rather abundant in the limestone over the main coal No. 11, at Providence, Hopkins county; also in a limestone over an equivalent coal on the property of Edward and William Hawes, near Hawesville, Hancock county, Kentucky.

GERVILLIA LONGISPINA. *Cox.*

(Pl. VIII, fig. 6, left valve natural size.)

Lunate; hinge area straight; posterior ear defined by a deep sinus; hollowed out on its lateral margin, and terminated by a long spine; beak depressed, pointed; anterior margin and base together form a semicircle; eliptically pointed at the posterior extremity; posterior border slightly concave, from which rises an abrupt ridge, gradually declining to the base and anterior border; anterior ear wanting; surface covered with fine striæ and strong marks of growth; length from beak to posterior extremity $1.\frac{43}{100}$ inches, height $.\frac{93}{100}$ inch. This remarkable species has no analogy with any other with which we are acquainted. A portion of the spine has been restored from fragments found in the rock.

Position and locality. Not uncommon in the limestone which overlays the main coal No. 11, at Providence, Hopkins county, Kentucky.

PLICATULA STRIATO-COSTATA. *Cox.*

(Pl. VIII, fig. 7; right valve natural size.)

Triagonal; inequilateral; right valve moderately convex; from nine to ten large elevated ribs arise irregularly below the beak, increasing in size to the circumferance, separated from one another by deep furrows, crossed about one-third the length above the base by an irregular concentric groove, below which, on the anterior side, the ribs are slightly bent forward, giving the appearance of having been broken; above this are two other rather indistinct bands; surface and ribs covered with fine irregular thread-like striæ, increasing by intercalation, rising from

each side, and terminate on the summit of the ribs, numbering, at three lines from the beak, sixteen in the space of two lines; base semicircular, crenulated; height 1.$\frac{08}{100}$ inches; width 1.$\frac{25}{100}$ inches.

Position and locality. From the limestone over the main Providence coal, No. 11, Hopkins county, Kentucky.

MYALINA PERNAFORMIS. *Cox.*

(Pl. VIII, fig. 8; right valve natural size.)

Sub-quadrate; inequilateral; beak pointed, projecting beyond, and moderately curved over the cardinal border; cardinal border nearly straight; anterior margin and base rounded; posterior margin straight; near which a prominent ridge gradually slopes to the front and base; surface covered with strong concentric, somewhat fimbriating lines of growth; length 1.$\frac{13}{100}$ inches; width .$\frac{67}{100}$ inch.

Position and locality. Common in the limestone over the main coal No. 11, at Providence, Hopkins county, Kentucky.

PLEUROTOMARIA DEPRESSA. *Cox.*

(Pl. VIII, fig. 19, 10a; natural size.)

Small; lenticular; depressed; about five volutions scarcely elevated; nearly flat above; defined by a row of acutely pointed tubercles, not so wide as the intervening notch; last whorl obtusely rounded below, bordered by a sharp edge, which has a narrow depressed band above, only visible when the implanted tubercles are removed; ornamented on the upper and lower side with obsolete lines of growth bent backwards; umbilicus shallow; mouth notched; columella and outer lip rounded; height .$\frac{33}{100}$ inch; width .$\frac{51}{100}$ inch; spiral angle 130°.

This species may at first easily be mistaken for *P. sphærulata, Conrad,* (*P. coronula Hall; Stansbury's expedition to the Great Salt Lake,* 1852, *page* 413, *pl.* 4, *fig.* 6,) but is much more depressed, and the angle of the last whorl more acute. The tubercles not so numerous, and less elevated.

Position and locality. Common in the shale forming the roof of No. 11 coal, at Bonharbour, Daviess county, and Airdrie, Muhlenburg county, Kentucky.

CARDINIA ? FRAGILIS. *Cox.*

(Pl. VIII, fig. 9; left valve natural size.)

Shell very thin; transversely ovate; beak scarcely elevated; anterior slope slightly hollowed; anterior extremity short, rounded below; base and posterior side obtusely rounded; hinge line straight, slightly truncated behind the beak; surface covered with broad concentric furrows; height $.\frac{92}{100}$ inch; width $1.\frac{20}{100}$ inches.

It is difficult, from the poorly preserved specimens now collected, to determine the genus with certainty; but believing it to be a characteristic shell, have placed it conditionally amongst the cardinia. When well preserved the valves may be found ornamented with fine concentric striæ.

Position and locality. Abundant in the black shale, which sometimes forms the roof of No. 11 coal, at Airdrie, Muhlenburg county, Kentucky.

MACROCHEILUS GRACILIS. *Cox.*

(Pl. VIII, fig. 11, enlarged; fig. 11 *a*, natural size.)

Small; conical; about six volutions; convex; suture small; last whorl half the length of entire shell; columella lip elongated; slightly refected; mouth subovate; length $.\frac{25}{100}$ inch; width $.\frac{15}{100}$ inch; spiral angle 56°.

It differs from *M. acutus, Sow.*, by the more rapid increase of the whorls, prolougation of the columella lip, and less rotundity of the mouth. Though the specimen under description is most likely a young shell, it cannot be confounded in any stage of developement with its cogenitors.

Position and locality. Common in the shale over No. 11 coal, Bonharbor, Daviess county, Kentucky.

ORTHIS RESUPINOIDES. *Cox.*

(Pl. IX, fig. 1, end view, natural size; fig. 1 *a*, entering valve; fig. 1 *b*, profile.)

Hinge line straight; less than the width of the shell; cardinal area well marked, gradually sloping back on the receiving valve; large angular foramen; both valves covered with fine thread-like striæ, radiating from the beaks to the circumference, numbering on the disk thirteen in $.\frac{12}{100}$ of an inch, crossed by fimbriating lines marking stages of growth; obsolete on the umbo; well marked and more numerous from the base for one third the length; receiving valve moderately convex;

greatest depth at the umbo; beak small, acute, elevated above and gradually sloping, with a slight depression to the sides; entering valve remarkably ventricose, and a little longer than the receiving valve; greatest depth at the disk; a very obscure shallow sinus is perceptible, running from the rostrum to the disk, where it is lost or obliterated by the crushed condition of the base of the shell; surface ornamented with five or six broken spines, two lines in diameter and about the same height, and several scars of missing spines; beak very tumid, acutely terminated, slightly incurved, moderately arched on the cardinal margin; sides obtusely rounded, broad and distinctly marked by rugose fimbriating lines of increment; width $1.\frac{86}{100}$ inches; length $1.\frac{54}{100}$ inches; hinge line $1.\frac{02}{100}$ inches; depth of receiving valve $.\frac{35}{100}$ inch; depth of entering valve $.\frac{95}{100}$; width of cardinal area $.\frac{12}{100}$ inch; depth $.\frac{07}{100}$ inch.

Though several authors have suggested the appearance of scars left by spines, on some species of orthis; this is believed to be the first specimen of the genus upon which they have actually been found attached.

The great convexity of the entering valve, the obtuseness of both valves at their lateral border, and the greater prolongation of the entering valve, distinguishes this species from the *O. resupinata*, (Mart. sp.,) to which it is most nearly related.

Position and locality. From the siliceous micaceous shale forming the roof of the upper coal, No. 11, at Mr. Hawes' mine, Hawesville, Hancock county, Kentucky.

AVICULA RECTA-LATERAREA. *Cox.*

(Pl. IX, fig. 2, right valve natural size.)

A little higher than broad; inequilateral; slightly oblique; covered with numerous radiating ribs, increasing in number by the intercalation of new ones, occasionally by dichotomy; nearly as high as broad; a little wider than the space which separates them from one another; anterior ear extends to the lateral border, with which it nearly forms a right angle; posterior ear a little shorter than the anterior, is not terminated by an angle, but by a rounded and well defined by a notch at its base; umbo slightly tumid, crossed by irregular concentric wrinkles; surface and ears covered with fine striæ, and fimbriating lines of increment; anterior side rectalineal; base and posterior side obtusely

rounded; hinge area straight; a little narower than the shell; height $.\frac{89}{100}$ of an inch; width $.\frac{86}{100}$ of an inch; anterior ear $.\frac{40}{100}$ of an inch; posterior ear $.\frac{38}{100}$ of an inch.

It is easily distinguished from *A. papyracea, Sow.*, with which it has been confounded, by the absence of a notch on thè side, at the extremity of the anterior ear, and from the *A. subpapyracea, De Ver.*, with which it is more nearly related, by its less obliquity, straight anterio-lateral margin, wrinkles on the umbo, and simple ribs.

Position and locality. It is most usually found converted into yellow pyrites, and in great abundance in the black shale forming the roof of No. 9 coal, at the Kentucky Coal Company's and Curlew mines, Union county, Kentucky, and in the equivalent beds of Gallatin county, Illinois.

A species, which we have not been able to distingnish from this, occurs also, but not as abundant, in coal No. 11, at "Thompson's vein," at Curlew mines, Union county, and at Bonharbour, Daviess county, Kentucky.

AVICULA ACOSTA. *Cox.*

(Pl. IX, fig 3; right valve natural size.)

Small; inequilateral; very oblique; sub-elliptical; wings terminating in small acute angles; anterior half as broad as the shell; posterior very small; surface and wings covered with fine concentric striæ; no ribs; height $.\frac{44}{100}$ of an inch; width $.\frac{42}{100}$ of an inch cardinal border $.\frac{30}{100}$ of an inch.

Position and locality. This small and fragile species is found in great abundance in the roof shales of No. 9 coal, in Union county, Kentucky, and equivalent beds, Gallatin county, Illinois, and appears to be characteristic of this vein, not having yet been found in any other position.

NAUTILUS DECORATUS. *Cox.*

(Pl. IX, fig. 4, profile natural size; fig. 4 a, portion of the same showing, *septum* and *siphuncle*; fig. 4b, outline of the septu.

Discoidal; whorls two and a half, not embracing, increasing in width in the proportion of $.\frac{36}{100}$ to $.\frac{81}{100}$ of an inch; obtusely rounded on the periphery; sides slightly convex; deeply plicated, forming elevated ridges, one to each septa, and curved in the same direction; a depression in their centre produces two rows of small tubercles, more promi-

nent on the last than preceding whorls, most decided on the outer edge; septu along the central third of the periphery slightly curved backwards; regularly curved backwards on the sides; where the shell has been well preserved it is closely covered with fine striæ, strongly arched backwards, on the periphery, into tongue shaped markings; siphuncle medium size; central or nearly central; umbilicus open, showing all the whorls; mouth transverse, subreniform; vertical height .$\frac{54}{100}$ of an inch; transverse diameter .$\frac{81}{100}$ of an inch; greatest diameter of the shell 1.$\frac{35}{100}$ inches; depth of septu next to the last chamber .$\frac{04}{100}$ of an inch.

This beautifully ornamented *Nautilus*, differs from the *N. tuberculatus*, *Sow.*, with which it is most nearly related, in not being concave on the sides, as well as in its markings and the outline of its septu.

Position and locality. It is found crushed in the roof shales of No. 9 coal, at the mines of the Kentucky Coal Company, Union county, Kentucky, and in a more perfect state of preservation in the fossiliferous nodules of calcareous sulphuret of iron in the same shale; which, when thrown out, decompose, from the action of the atmosphere and yield readily their store of fossils to the collector.

SOLENIMYA SOLENIFORMIS. *Cox.*

(Pl. IX, fig. 5; natural size.)

Transversely elongated; inequilateral; beaks not elevated, sloping to the front, about one-third the length from the anterior end; extremities and base obtusely rounded—more decided anteriorly in young than in adult specimens; cardinal border straight; surface covered with concentric lines and furrows; length 2.$\frac{74}{100}$ inches; width 1.$\frac{45}{100}$ inches.

Position and locality. It is very abundant in the black shale which forms the roof of No. 9 coal, on the property of the Kentucky Coal Company, Union county, Kentucky, and in the same character of shale, over the thirteen inch coal, in the bed of the Ohio river, at the head of French Island.

PRODUCTUS MURICATUS. *Norwood and Pratten.*

Pl. IX, fig. 6; natural size.)

For description, *see Journal Academy Natural Sciences, Aug.*, 1854, *pl.* 1, *fig.* 8.

Position and locality. Characteristic of coal No. 9, and found in great abundance in the black shale forming its roof, at the Curlew and Kentucky Coal Company's mines, Union county; at Lewisport, Hancock county, Kentucky; and at the Saline and Shawneetown Company's mines, Gallatin county, Illinois.

GONIATITES NOLINENSIS. *Cox.*

(Pl. X, fig. 1, quarter view natural size; fig. 1*a*, outline of dorsal septu;* fig. 1*b*, outline of ventral septu.)

Discoidal; one and a half to two whorls, increasing in the proportion of $.\frac{70}{100}$ of an inch to $1.\frac{25}{100}$ inches; periphery very convex; sides obtusely rounded; umbilicus large, round, vertically walled; dorsal lobe and sinus dart shaped, first lateral lobe elliptically pointed, a little longer and broader than the dorsal; lateral sinus angular, acutely pointed, about twice as broad, and one-third longer than the dorsal; second lateral lobe subovately rounded; ventral sinus longer and more acute than the corresponding dorsal lobe; second ventral lobe obtusely rounded, and broader than the lateral sinus, with which it corresponds; mouth moderately transverse; greatest diameter $2.\frac{17}{100}$ inches; width of umbilicus $.\frac{45}{100}$ of an inch; transverse diameter of mouth $1.\frac{25}{100}$ inches; vertical hight $1.\frac{08}{100}$ inches.

It is closely related to *G. crenistria, Phill.*, but differs in having the last chamber less transverse; umbilicus larger, and the dorsal lobe acutely pointed; not bifid as in the *G. crenistria.* The specimens found are not well enough preserved to show any ornaments that may have existed on the shell, they are all converted into oxide of iron; and like their associates *N. ferratus, nob.* and *N. canaliculatus, nob.* have been used at Nolin Furnace for the manufacture of iron.

Position and locality. Nolin Iron Works Edmonson county, Kentucky, in a thin stratum of ferruginous fire-clay with fragments of coal closely resembling charcoal, about one hundred feet above the conglomerate.

NAUTILUS FERRATUS. *Cox.*

(Pl. X, fig 2, half natural size; fig. 2*a* section natural size.

Globose, convoluted, whorls two, embracing, increasing in width in the proportion of $1.\frac{45}{100}$ inches to $2.\frac{71}{100}$ inches, regularly rounded on

*Explanation of the nomenclature. Fig. 1*a*, the arrow is in the dorsal lobe, and points to the mouth in the direction of increase; *d*, dorsal lobe; *d*, *s*, dorsal sinus; *l'*, first lateral lobe; *l*, *s'*, first lateral sinus; *l''*, second lateral lobe. Fig. 1*b*, *v*, *s*, ventral sinus; *v*, *l'*, first ventral lobe; *v*, *s''*, second ventral sinus; *v*, *l''*, second ventral lobe.

the periphery and sides; septu obtusely curved backwards on the sides, rapidly rising forward into conical arches on the middle of the periphery, about three lines apart in the middle where two inches wide; periphery marked in casts with an obsolete band about one line in width; last chamber large, about as deep as wide; mouth subreniform; umbilicus moderately large, profound, nearly vertically walled, slightly enlarged on the last whorl. Diameter 3.$\frac{32}{100}$ inches; transverse diameter of mouth about 2.$\frac{71}{100}$ inches; vertical height 1.$\frac{64}{100}$ inches; width of umbilicus $\frac{34}{100}$ of an inch.

It is readily distinguished from *N. globatus, Sow.*, and *N. bilobatus, Sow.*, with which it is related; by the size and shape of its septu, and the less rapid increase of its whorls. The specimen under description is destitute of spiral or transverse striæ, though it is possible they may exist when found in a more perfect state of preservation.

Position and locality. Found in great abundance, converted into oxide of iron and mostly imperfect; associated with *G. Nolinensis, nob.* about one hundred feet above the conglomerate, in a stratum of ferruginous fire-clay and carbonaceous matter; Nolin Iron Works, Edmonson county, Kentucky. Being an excellent ore it has contributed largely for the manufacturing of iron.

NAUTILUS CANALICULATUS. *Cox.*

(Pl. X, fig. 3, natural size; fig. 3 *a*, section of a smaller specimen.)

Discoidal, whorls two, to two and a half, increasing in width in the proportion of .$\frac{50}{100}$ to 1.$\frac{30}{100}$ inches; obtusely rounded on the sides; broad, but shallow groove on the periphery, diminishing in depth from the mouth backwards, obsolete on the first whorl when exposed, a narrow indistinct band extends along the centre of the dorsal groove in well preserved specimens; septu about two lines apart in the middle, where three quarters of an inch in width, curved backwards on the sides and periphery, on the rounded edges of the groove they bend semi-elliptically forward; umbilicus large, deep, vertically walled, exposing partially all the whorls; mouth transversely subovate; diameter 2.$\frac{51}{100}$ inches; vertical height of the mouth, about 1.$\frac{30}{100}$ inches; transverse diameter 1.$\frac{45}{100}$ inches; width of umbilicus .$\frac{42}{100}$ of an inch.

It differs from the *N. sulcatus, Phil.*, by its rounded sides, greater breadth on the periphery, smaller and more vertically walled umbilicus.

Position and locality. Abundant in the same bed with *G. Nolin-*

sis and *N. ferratus*. Nolin iron works, Edmondson county, Kentucky.

LINGULA UMBONATA. *Cox.*

(Pl. X, fig. 4, entering valve enlarged; fig. 4 *a*, natural size.)

Subpentagonal, longitundinally elongated, very tumid at the umbo; beak elevated, pointed, not projecting beyond the cardinal border; greatest width about one-third the length below the beak; sides nearly parallel, slightly convex and narrowing towards the front; front very obtusely rounded, posterior lateral margins rather acutely rounded, uniting in an elliptical point at the beak; slightly flattened along the mesial line, commencing from a point near the beak, and gradually widening to the front margin, a little pinched in near the umbo; surface beautifully marked with fine concentric striæ between the more distinct lines of growth; length .$\frac{19}{100}$ of an inch; width $\frac{13}{100}$ of an inch.

This species is easily recognized in well preserved specimens, by its prominent umbo, and its peculiar longitudinally flattened mesial area. It attains a much greater size, but we have none larger sufficiently perfect to figure.

It is highly characteristic of No. 1, B, coal, and has been found in beds of this level, by Mr. Lesquereux, in Ohio and Pennsylvania.

Position and locality. Very abundant in the black slate roof of No. 1, B, coal, at Bell's mines, Crittenden county; Casey's mines, Union county, and Hawesville mines, Hancock county, Kentucky.

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